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Electrocardiographic alterations in young high-performance athletes

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ABSTRACT

Introduction: Physical exercise is extremely beneficial to health; but in the case of athletes, intense sports training develops morphological and physiological changes in the heart. Many of these changes, called "normal or physiological", and other "abnormal or pathological" findings –which could suggest the presence of underlying cardiovascular disease– can be detected by an electrocardiogram.
Objectives: To identify electrocardiographic disorders present in young high-performance athletes of a soccer club.
Method: Forty male athletes were studied in the period January to June 2019. The athletes were evaluated by questioning, physical examination and electrocardiogram at rest.
Results: A number of normal electrocardiographic findings –according to the international criteria for electrocardiographic interpretation in athletes– were found. Sinus bradycardia was the most frequent (60%). The isolated appearance of right axis deviation (>120°) and complete right bundle branch block were the only borderline findings. The presence of inverted T waves (10%), intraventricular conduction disorders (7.5%) and anomalous Q waves (5%) were the most frequent pathological findings.
Conclusions: The twelve-lead electrocardiogram remains an important means of detecting physiological electrocardiographic findings related to sports training in high-performance athletes, as well as abnormal or pathological alterations that may be suggestive of cardiovascular disease, in addition to being triggering risk factors for sudden cardiac death.
Keywords: Electrocardiography, Exercise, Sudden cardiac death, Cause of death

Alteraciones electrocardiográficas en jóvenes atletas de alto rendimiento

RESUMEN

Introducción: El ejercicio físico genera beneficios para la salud, pero en el caso de los atletas el entrenamiento deportivo intenso desarrolla cambios morfológicos y fisiológicos en el corazón. Muchos de estos cambios, denominados «normales o fisiológicos», y otros hallazgos «anormales o patológicos» –que sugieran la existencia de una enfermedad cardiovascular subyacente– pueden ser detectados con la realización de un electrocardiograma.
Objetivo: Identificar los trastornos electrocardiográficos presentes en jóvenes atletas de alto rendimiento de un club deportivo de fútbol.

Método: *Se estudiaron 40 atletas del género masculino en el período de enero a junio de 2019. Los deportistas fueron evaluados mediante interrogatorio, examen físico y electrocardiograma en reposo.*
Resultados: *Fueron detectados múltiples hallazgos electrocardiográficos normales, según los criterios internacionales para su interpretación en deportistas. La bradicardia sinusal (60%) fue el más frecuente. La aparición aislada de desviación del eje eléctrico hacia la derecha (> 120°) y el bloqueo completo de rama derecha, resultaron los únicos hallazgos limítrofes encontrados. La presencia de ondas T invertidas (10%), trastornos de conducción intraventricular (7,5%) y ondas Q anómalas (5%) fueron los hallazgos patológicos que con mayor frecuencia se detectaron.*
Conclusiones: *El electrocardiograma de doce derivaciones constituye un estudio importante para la detección de hallazgos electrocardiográficos fisiológicos relacionados con el entrenamiento deportivo en atletas de alto rendimiento, así como de alteraciones anormales o patológicas que sugieran la existencia de enfermedad cardiovascular y constituyan un factor de riesgo desencadenante de muerte súbita de origen cardíaco.*
Palabras clave: *Electrocardiografía, Ejercicio, Muerte súbita cardíaca, Causa de muerte*

INTRODUCTION

The cardiovascular system has the function of providing the blood necessary to meet the metabolic needs of each of the tissues that make up the body. Within this system, the heart is a muscular organ that has its own energy and it is responsible for pumping the blood depending on these needs. During physical exercise, the metabolic demand increases, especially at the expense of oxygen consumption by muscle tissue. In order to meet this demand, the cardiac function experiences changes that lead to increased cardiac output[1].

Multiple studies demonstrate the benefits of physical exercise, not only causing changes that favor the body composition of the person and strengthening structures of the musculoskeletal system, but benefits that contribute to increased respiratory efficiency and improved quality of life[2].

Sports physical activity can be classified according to its formality as[3]:

- Formal: where the important thing is strictly the result of the competition and it is performed by professionals who develop a body workout planned to maintain or improve their physical fitness components.
- Semiformal: in which competitiveness is preserved, but athletes do not have intense training and do not participate in official competitions.
- Informal: when it has a recreational character and it is developed in the free time of the individual.

Sports training develops a series of adaptations in the heart at both, morphological and functional levels, which can be referred to as the "athletic heart syndrome", described for the first time, according to Yañez[4], by Henschen, at the end of the XIX century. Aspects such as the type of sport that is performed, duration and intensity of training and years of practice influence the development of these adaptations.

In published studies are reported positive effects on in athletes' cardiovascular health due to physical activity and sports. However, in the case of intense sports, it has also been shown increased risk of cardiovascular events and the occurrence of sudden death of cardiac origin[1]. An athlete is considered elite if the training is for six hours or more a week, and regularly competes at the regional, national or international level[5].

The electrocardiogram at rest is considered an important tool from the point of view of cost/effectiveness for the athletes' assessment. Through this test are registered morphophysiological changes occurring in the heart as a result of maintained formal physical activity, considered normal, and it may show, in addition, other abnormal findings or pathological signs suggesting the existence of an underlying cardiovascular disease. The latter can alert the medical professional of the presence of a predisposing condition and trigger of sudden death in this group of people[6].

Considering all the aforementioned, we have developed the present study with the aim of identifying electrocardiographic disorders present in young

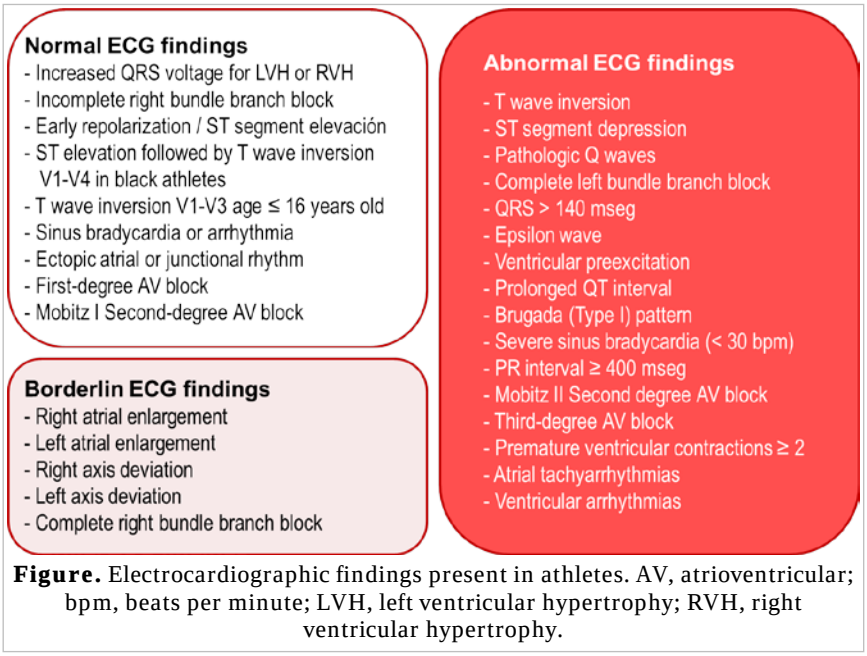

Figure. Electrocardiographic findings present in athletes. AV, atrioventricular; bpm, beats per minute; LVH, left ventricular hypertrophy; RVH, right ventricular hypertrophy.

high-performance athletes of a football sports club.

METHOD

A prospective descriptive cross-sectional study was carried out in the period from January to June 2019, in the *"Club Deportivo Delfín Sc."* from the city of Manta, Manabí Province, Ecuador.

A total of 40 athletes were studied, all of them males, belonging to the reserve league, whose ages were between 17 and 22 years. These were interrogated and evaluated in the consultation and underwent, in supine position, a 12-lead electrocardiogram at rest, with an electrocardiograph BTL-08 MT PLUS model of 12 channels, with prints in 112 mm format.

The analysis of the obtained traces was made according to the recommendations for the interpretation of the 12-lead electrocardiograms in the athlete, from the last international consensus of cardiologists and sport physicians published by the British Journal of Sports Medicine in 2017[7]. The electrocardiographic findings were determined and gathered into three groups or categories (**Figure**): normal findings found in athletes (related to training), borderline findings (previously classified as abnormal), and abnormal findings.

All electrocardiograms were interpreted by two evaluators and if there were different opinions, a third evaluator was consulted. The results obtained were processed by univariate statistical analysis and presented in tables.

RESULTS

From the total number of athletes who made up the study, the majority (75%) were mestizos, seven Afro-Ecuadorians and only 3 whites. Their ages were between 17 and 22 years, with an average of 19 years. The anthropometric measurements obtained revealed weights between 52 and 84 kg, with an average of 62 kg; also an average size of 177 cm (range 159-187 cm). The cal-culation of the body mass index showed that the total of athletes studied were in the normal range (between 18.5 to 24.9 kg/m^2), with an average for this variable of 20 kg/m^2.

Regarding the years of dedication to sports practice (**Table 1**), it was found that most of the athletes had more than one year linked directly to the sport; of these, 62.5% expressed to be between one and five years belonging to the professional reserve league, while 15% belonged to the club during a period larger than five years.

Among the normal electrocardiographic findings observed (**Table 2**), the sinus bradycardia was first highlighted, between 30 and 60 beats per minute (60%). Second, the partial or incomplete right bundle branch block pattern (42.5%) and thirdly the left ventricle hypertrophy with increases in the QRS voltage (SV_1 + RV_5 o RV_6 > 35 mV).

As borderline findings only the presence isolated deflection of the electric axis to the right, more than 120°, was evidenced, as well as the full right bundle

Table 1. Distribution according to years of sports practice.

Sports practice (years)	Nº	%
Less than 1 year	9	22.5
1-5 years	25	62.5
More than 5 years	6	15.0
Total	40	100.0

branch block. Finally, among the abnormal electrocardiographic findings in the study (**Table 3**), it was observed that the most frequent were: inverted T wave in the 10% of athletes (depth ≥ 1 mm, at the least, two contiguous leads); followed by intraventricular conduction disorders QRS ≥ 140 ms (7.5%) and pathological Q waves with ratio Q/R ≥ 0.25 or Q ≥ 40 ms in at the least two leads (5%). Other abnormal findings were evidenced in isolation, like the third-degree atrioventricular block and the ventricular preexcitation with short PR interval of 110 ms, delta wave and QRS width of 122 ms.

Table 2. Normal electrocardiographic findings found in athletes (n=40).

Electrocardiographic findings	Nº	%
Left ventricular hypertrophy pattern	10	25.0
Right ventricular hypertrophy pattern	1	2.5
Incomplete right bundle branch block	17	42.5
Sinus bradycardia	24	60.0
Respiratory sinus arrhythmia	9	22.5
First-degree atrioventricular block	3	7.5

Table 3. Abnormal electrocardiographic findings in athletes (n=40).

Hallazgos electrocardiográficos	Nº	%
Inverted T wave	4	10.0
Pathological Q wave	2	5.0
Intraventricular conduction disorder	3	7.5
Ventricular preexcitation	1	2.5
Third-degree atrioventricular block	1	2.5

DISCUSSION

The ethnic distribution evidenced in this research coincides with the data obtained from the *Secretaría Nacional de Planificación y Desarrollo de Ecuador*, which, according to an analysis of the *Agenda Regional de Población y Desarrollo* after 2014, suggests that 71.9% of Ecuadorians identify themselves as mestizos[8].

The total number of athletes studied were linked to sports with a daily training rate of 90 minutes from Monday to Friday, plus two 45-minute times of games on Saturdays, achieving approximately nine hours of physical activity weekly. This training load was directly related with the electrocardiographic findings identified as normal, which −according to the consensus published to this date− are commonly observed in athletes and are directly related to the intensity and workout time; reason why they are considered as normal[7,9]. Among these findings, the sinus bradycardia was the most common, and it may appear until more than 50% of high-performance athletes[10,11], which coincides with what was found in our study.

Since in 2005 were published the first recommendations for the interpretation of the electrocardiograms in athletes[12], there have been some changes in terms of the elements that can be classified as normal or abnormal. Meetings of experts have taken place in different parts of the world with the analysis and the disclosure of new criteria and consensus[13,14] up to the last published in 2017[7], in which a new category is included, which are the borderline electrocardiographic findings.

These alterations, previously considered as within the category of abnormal findings, may appear in isolation in athletes who have no symptoms or association to events of sudden death or history of hereditary heart disease. In that case, conducting studies for further evaluation must not be considered in these athletes. Nonetheless, if present in number of two or more, additional examinations are actually indicated, in order to research for possible pathological cardiovascular disorders associated with sudden death[15].

The abnormal electrocardiographic findings in athletes do not commonly appear published, but they are considered as important causes of sudden death of cardiovascular origin in these specific group of people. The myocardial hypertrophy is the most frequent cause described in the bibliography, but other diseases such as channelopathies, congenital abnormalities of the coronary arteries and arrhythmogenic right ventricular dysplasia[16,17] must be considered as well. None of the above match those found in our study, but it is equally considered im-

portant to emphasize that athletes where such findings are detected must have further complementary assessments, among which are the Holter, the stress test and imaging tests, mainly the echocardiogram and the nuclear magnetic resonance, to evidence the cardiovascular disease and treat it in the best way, according to the protocols established for the sports qualification and temporary or permanent disqualification[7,11,18-20].

CONCLUSIONS

The practice of physical activity causes electrocardiographic changes that are considered normal in elite athletes. Nevertheless, the existence of abnormal or pathological findings suggests the existence of associated cardiovascular disease, which is a risk factor triggering events that can be fatal as sudden cardiac death. Therefore, we conclude that all elite athletes require one initial cardiovascular assessment and on periodic basis, in order to achieve timing diagnosis and health care.

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