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Study of electrocardiogram in competitive athletes

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ABSTRACT

Background: Sudden death in athletes is a major concern; the predictors and value of prior investigations remain to be settled. The work aims at studying electrocardiograms (ECG) in competitive athletes to define incidence of abnormalities and any relevant associations.
Methods: The study included hundred persons engaged in competitive sports for duration not less than 6 months; with training at least 3 days per week and at least two hours per day. Full history especially questioning for syncope, tachycardias or chest pain was obtained as well as family history of sudden death or coronary disease; examination for BP, any cardiac murmurs or arrhythmia. ECG was done for all plus echo Doppler in some cases.
Results: During the period from 1/1/2015 to 1/10/2016, 100 athletes were screened by ECG, 54 played isotonic sport while 46 were on isometric sport. Types of sports: isometric (static) (body builders) 46. Isotonic (dynamic) 54 (Bicycling 6, Football 15, Tennis 3, Basketball 16, Volleyball 8, Swimming 4, Boxing 2) . Echo was done in 15, increase in LV size was found in 5 (Diastolic diameter up to 61mm). Follow up by telephone questionnaire was done for all, 5 persons were re-examined after months, no abnormal events were found. Results: Data given total then in isometric (static) group then isotonic (dynamic) group then P value respectively: LV hypertrophy by voltage criteria 18%, 24%, 10.9%, p 0.087. Early repolarization in 5%, 9.3%, 0%, P 0.06. RSR' in V1 (and V2 in some cases) 14%, 20%, 6.5%, P 0.047. Inverted T 3%, 3.7%, 2%, P =1. Total ECG changes of any form 43%, 59%, 23.9%, P 0.001. The significance of finding more ECG changes in isometric (static) athletes is not clear but clinically did not show any effect. Correlation between the 18 athletes with ECG LVH and echocardiography: only 5 of the 18 showed increased diameters by echo but within accepted athletic heart criteria. Two of body builders confessed of taking doping drugs (male hormones) but no clinical abnormal signs were detected. No long QT was found.
Discussion: We did not find cases of hypertrophic cardiomyopathy, valvular heart disease, arrhythmogenic syndromes or congenital heart disease. Conclusions: Routine ECG for all competitive athletes is not recommended, it is only indicated if persons have symptoms as syncope or chest pain or tachyarrhythmia.

Key words: ECG , athletes, SCD.

INTRODUCTION

The competitive athlete has been described as one who participates in an organized team or individual sport requiring systematic training and regular competition against others. The purpose of screening, as described here, is to provide medical clearance for participation in competitive sports through routine and systematic evaluations intended to identify clinically relevant and preexisting cardiovascular abnormalities and thereby reduce the risks associated with organized sports. (Maron, Thompson et al. 1996, Maron, Thompson et al. 2007).

Sudden cardiac death (SCD) associated with athletic activity is a rare but results in significant public and media attention (Chaitman 2007).

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Sports are classified into isotonic and isometric sports. Sports characterized by relatively pure isotonic stress include long-distance running, soccer, and cross-country skiing. Relatively pure isometric stress sports include weightlifting, martial arts, and track and field throwing events. Athletes participating in these “pure stress” sporting disciplines have been used to define the concept of sports-specific exercise-induced cardiac remodeling.

Isotonic stress stimulates a form of exercise-induced remodeling characterized by biventricular dilation, biatrial dilation, and enhanced left ventricular diastolic function.(Kovacs and Baggish 2016).

In contrast, isometric stress stimulates remodeling confined to the left ventricle that is typically characterized by mild degrees of concentric left ventricular hypertrophy with unchanged or relative impairment of diastolic function. It is noteworthy that many of the most popular sports involve significant amounts of both isotonic and isometric cardiovascular stress. As anticipated, individuals who participate in “physiology overlap sports” (i.e., concomitant high isometric/high isotonic) including competitive cycling and rowing typically demonstrate the most robust cardiac adaptations with elements of both pressure- and volume-mediated remodeling.(Kovacs and Baggish 2016).

These physiological ECG changes should be clearly separated from uncommon (<5%) and training-unrelated ECG patterns such as ST-T repolarization abnormalities, pathological Q-waves, left-axis deviation, intraventricular conduction defects, ventricular pre-excitation, long and short QT interval and Brugada-like repolarization changes which may be the expression of underlying cardiovascular disorders, notably inherited cardiomyopathies or ion-channel diseases which may predispose to SCD. (Biffi, Delise et al. 2013).

PATIENTS AND METHODS

Subjects:

The study included hundred subjects engaged in competitive sports for duration not less than 3_4 years and with training at least 3 days per week and at least one hour per day.

Inclusion criteria

- Any type of sport, football or basketball, swimming, weight lifting or running. They divided into two broad types: dynamic (isotonic) and static (isometric).
- Age range 18 to 45 years
- Only males.

Tools of data collection:

The subjects in the study was subjected to

History taking

Full history especially questioning for syncope or chest pain. Family history of sudden death or coronary disease.

Clinical examination

Examination for BP, any cardiac murmurs or arrhythmia. Weight and height to calculate body mass index.

Table-1. Classification of abnormalities of the athlete's electrocardiogram(Corrado, Biffi et al. 2009)

Group 1: common and training-related ECG changes	Group 2: uncommon and training-unrelated ECG changes
Sinus bradycardia	T-wave inversion
First-degree AV block	ST-segment depression
Incomplete RBBB	Pathological Q-waves
Early repolarization	Left atrial enlargement
Isolated QRS voltage criteria for left ventricular hypertrophy	Left-axis deviation/left anterior hemiblock
	Right-axis deviation/left posterior hemiblock
	Right ventricular hypertrophy
	Ventricular pre-excitation
	Complete LBBB or RBBB
	Long- or short-QT interval
	Brugada-like early repolarization

Table-2. Demographic characteristics of athletes in the study.

	No.	Percent	Mean / SD
Age (year)			23.30 ± 4.63
BMI			24.19 ± 2.93
Sex			
Males	100	100	
Governorate			
Alexandria	100	100	
Medical History			
Hypertension	11	11	
symptoms	9	9	
Family History	1	1	
Smoking	7	7	

Investigations

- ECG was done for all and examined for rate, rhythm, voltage, ST, QT and recording of any abnormality. A standard 12-lead ECG was performed on competitive athletes who are apparently normal in the supine position during quiet respiration and recorded at 25 mm per second. The ECG tracing was obtained at least 24 hours after the last athletic activity.

- Echocardiography was done for cases that are suspicious. Echo measured LV size (diameters, mass index), any valvular lesions, pulmonary hypertension and right ventricular measurements.

Statistical analysis of the data:

Data were analyzed using software (SPSS 23). Descriptive data was expressed in frequency and percent and was analyzed using Chi-square test also exact tests such Fisher exact and Monte Carlo was applied to compare different groups. P value was assumed to be significant at (0.05) with confidence interval set at 95%.

RESULTS

During the period from 1/1/2015 to 1/10/2016, 100 athletes were screened by ECG. 54 played isotonic sport while 46 were on isometric sport. According to the past medical history: 11 (11%) patients were hypertensive, 9(9%) were symptomatic, 1 (1%) was with positive family history for cardiac diseases and seven (7%) were smokers.

Data given total then in isometric (static) group then isotonic (dynamic) group then P value respectively: LV hypertrophy by voltage criteria 18%, 24%, 10.9%, p 0.087. Early repolarization in 5%, 9.3%, 0%, P 0.06. RSR' in V1 (and V2 in some cases) 14%, 20%, 6.5%, P 0.047. Inverted T 3%, 3.7%, 2%, P =1. Total ECG changes of any form 43%, 59%, 23.9%, P 0.001. The significance of finding more ECG changes in isometric (static) athletes is not clear but clinically did not show any effect. Correlation between the 18 athletes with ECG LVH and echocardiography: only 5 of the 18 showed increased diameters by echo but within accepted athletic heart criteria. Two of body builders confessed of taking doping drugs (male hormones) but no clinical abnormal signs were detected. No long QT was found.

DISCUSSION

Sudden death in athletes is a major concern; the predictors and value of prior investigations remain to be settled. The work aims to study electrocardiograms (ECG) in competitive athletes to define incidence of abnormalities and any relevant associations.

During the period from 1/1/2015 to 1/10/2016, 100 athletes were screened by ECG, 54 played isotonic sport while 46 were on isometric sport in Alexandria.

The mean age of athletes was 23.3 years,and the mean BMI of athletes was 24.19.

We observed that (11%) athletes were hypertensive, (9%) were with cardiac symptom, (1%) was with positive family history for cardiac diseases and (7%) were smokers.

12 leads ECG was done to all athletes: LVH by voltage criteria were found in 18% of athletes, Early repolarization in 5%, bradycardia in 6%,RBBB in 14%, Inverted T in 3% and Sinus arrhythmia in 6% and we observed that 43% of all athletes were with at least one ECG changes ,while it was up to 60% of athletes as described by Leite, Sérgio Machado.(Leite, Freitas et al. 2016).

The most commonly used voltage criterion for LVH is the Sokolow-Lyon index. However, ECG QRS voltage may not be a reliable predictor of LVH.

In athletes, intensive conditioning is also associated with morphological cardiac changes of increased cavity dimensions and wall thickness that are reflected on the ECG. These changes constitute physiological LVH in trained athletes and usually manifests as an isolated increase in QRS amplitude,LVH are prevalent and present in up to 18% of athletes. Drezner JA, Fischbach P, Froelicher V, et al(Drezner, Ackerman et al. 2013) reported that present in up to 45% of athletes. A high prevalence of ECGs that fulfil Sokolow–Lyon voltage criteria for LV hypertrophy has been consistently reported in trained athletes assessed the prevalence and type of ECG abnormalities in 1005 elite Italian athletes, 75% male who participated in 38 sporting disciplines.(Biffi, Delise et al. 2013).

Early repolarization has traditionally been regarded as an idiopathic and benign ECG phenomenon, with a clear male preponderance. The early repolarization ECG pattern is the rule rather than the exception among highly trained athletes. The early repolarization ECG shows elevation of the QRS–ST junction (J-point) of at least 0.1 mV from baseline, associated with notching or slurring of the terminal QRS complex which may vary in location, morphology, and degree. These changes often are localized in precordial leads, with the greatest ST-segment elevation in mid-to-lateral leads (V3–V4), but maximal ST-segment displacement may also be seen in lateral leads (V5, V6, I, and aVL), inferiorly (II, III, and aVF), or anteriorly (V2–V3).

Early repolarisation is reported in up to 35–91% of trained athletes and is more prevalent in young males and black by Drezner JA, Fischbach P, Froelicher V, et al.(Drezner, Ackerman et al. 2013), 50% to 80% of all highly-trained athletes present have early repolarization reported by Scharhag, Jürgen(Scharhag, Lollgen et al. 2013) and it was observed in 50–80% of resting ECGs by Biffi, Alessandro(Biffi, Delise et al. 2013),and it was less than 10% of the 15,000 participants reported by Sinner, Moritz F(Sinner, Porthan et al. 2012),while it was only in 5% of the athletes in our study.

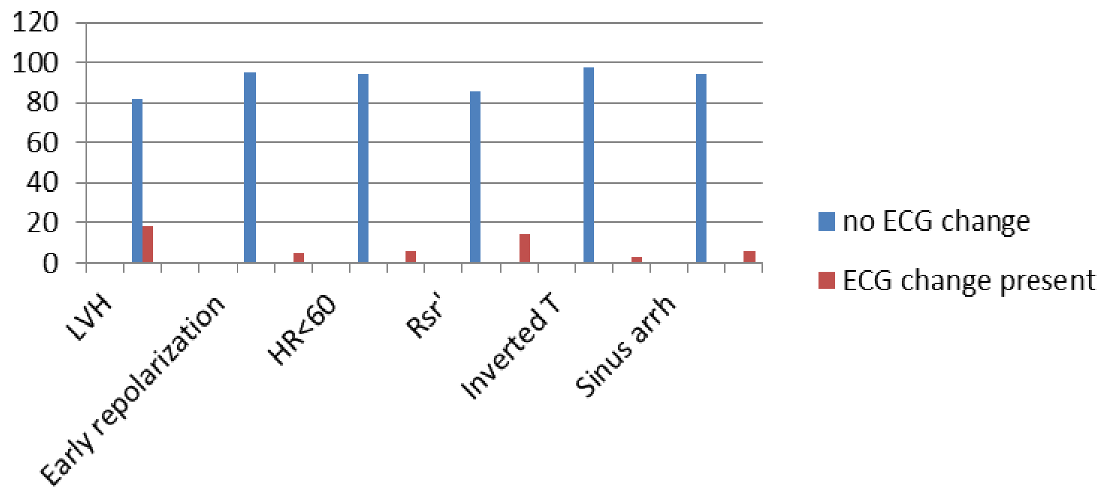
The normal heart beat is initiated by the sinus node which is located high in the right atrium near the junction of the superior vena cava and the right atrial appendage. To be classified as sinus rhythm, three criteria must be met: (1) there must be a P wave before every QRS complex, (2) there must be a QRS complex after every P wave and (3) the P wave must have a normal axis in the frontal plane (0–90°s). Assuming an intact sinus node, the heart rate is set by the balance between the sympathetic and parasympathetic nervous systems. In healthy adults, sinus rhythm < 60 beats/min is considered as ‘sinus bradycardia’.

Table-3. Relation between type sport with ECG changes.

ECG changes	Total (n=100)		Type sport				χ^2	p
			Isotonic (n=54)		Isometric (n=46)			
	No.	%	No.	%	No.	%		
LVH								
Absent	82	82.0	41	75.9	41	89.1	2.934	0.087
Present	18	18.0	13	24.1	5	10.9		
Early repolarization								
Absent	95	95.0	49	90.7	46	100.0	4.483	0.060
Present	5	5.0	5	9.3	0	0.0		
HR<60								
Absent	94	94.0	48	88.9	46	100.0	5.437*	$^{FE}p=$ 0.030*
Present	6	6.0	6	11.1	0	0.0		
Rsr'								
Absent	86	86.0	43	79.6	43	93.5	3.957*	0.047*
Present	14	14.0	11	20.4	3	6.5		
Inverted T								
Absent	97	97.0	52	96.3	45	97.8	0.200	$^{FE}p=$ 1.000
Present	3	3.0	2	3.7	1	2.0		
Sinus arrh								
Absent	94	94.0	50	92.6	44	95.7	0.412	$^{FE}p=$ 0.684
Present	6	6.0	7	7.4	2	4.3		

χ^2: Chi square test
FE: Fisher Exact for Chi square test
*: Statistically significant at $p \le 0.05$

Figure-1. Percentage of ECG changes among athletes



In well-trained athletes, resting sinus bradycardia is a common finding due to increased vagal tone, it was only in 6% of the athletes in our study.

IRBBB is defined by a QRS duration <120 ms with an RBBB pattern: terminal R wave in lead V1 (rsR') and wide terminal S wave in leads I and V6. IRBBB is observed in up to 40% of highly trained athletes according to Drezner JA, Fischbach P, Froelicher V, et al.(Drezner, Ackerman et al. 2013) ,and incomplete right bundle branch block (RBBB) was in 33% of the ethletes in van Dijk, Gaby Pons(van Dijk, van der Kooi et al. 2014), 35% to 50% of athletes have an incomplete right bundle branch block according to Scharhag, Jürgen(Scharhag, Lollgen et al. 2013) and The prevalence of incomplete right bundle branch block has beene stimated to range from 35 to 50% in athletes as written by Biffi, Alessandro(Biffi, Delise et al. 2013) ,while it was 14% of the athletes in our study.

T-wave inversion is defined as >1 mm in depth in two or more leads V2–V6, II and aVF, or I and aVL (excludes III, aVR and V1).

T-wave inversion in inferior (II, III, aVF) and/or lateral (I, aVL, V5–V6) leads must raise the suspicion of ischaemic heart disease, cardiomyopathy, aortic valve disease, systemic hypertension, and LV non-compaction. T-wave inversion listed as Abnormal and uncommon ECG findings in athletes and reported in 2% of athletes by Drezner, J.A., et al.(Drezner, Fischbach et al. 2013),and identified in only 0.1% to 0.2% of athletesvaccording to D'Silva, Andrew(D'Silva and Sharma 2014) ,while it was only 1.4% as descriped by Biffi, Alessandro(Biffi, Delise et al. 2013), and it was in 5% of the athletes in our study.

The heart rate usually increases slightly during inspiration and decreases slightly during expiration. This response called sinus arrhythmia can be quite exaggerated in children and in well-trained athletes resulting in an irregular heart rhythm which originates from the sinus node. It has been estimated that up to 55% of well-trained athletes have sinus arrhythmia reported by Drezner JA, Fischbach P, Froelicher V, et al.(Drezner, Ackerman et al. 2013)While we found sinus arrhythmia in 6% of the athletes.

At least we didn’t find any of uncommon ECG that was reported by Drezner, J.A., et al.(Drezner, Fischbach et al. 2013)/

Echocardiography was done in 15 players, increase in LV size was found in 5 players only.

Follow up by telephone questionnaire was done for all, 5 persons were re-examined after months, no abnormal events were found.

CONCLUSIONS

Now after determining ECG changes which are physiological (common and training related ECG changes) and pathological (uncommon), in this study we found that physiological changes represents about 43% of athletes and pathological changes were not present in young competitive athletes, so ECG is not indicated for routine screening in athletes and only indicated for those whom have symptoms as syncope or chest pain or tachyarrhythmia. Athletes with ECG changes due to cardiac adaptation to physical exertion should be reassured that they can continue to participate in competitive sports without additional investigation, in the absence of symptoms or a family history of cardiac disease or premature SCD.

Recommendations:

- Study should be performed on larger group for longer period of time.
- Careful assessment and follow up both clinically and ECG changes in compitive athelets.
- Routine ECG for all competitive athletes is not recommended, it is only indicated if persons have symptoms as syncope or chest pain or tachyarrhythmia.

Conflicts of Interest

Authors declare that there is no conflict of interests regarding the publication of this paper.

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