Analysis and Dispersion of QT, JT and Tpeak-Tend Intervals in Elite Female Water Polo Players

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ABSTRACT

Background
The physiology of water polo has been difficult to study due to the characteristics of the game in the field of play. Little is known about cardiac electrophysiology in these athletes, particularly in women. The electrocardiographic variables in elite water polo athletes have been rarely studied.

Objective
To analyze ventricular repolarization in female water polo players from the National Pre-selection Team of Cuba

Methods
A cross-sectional study was performed in two groups of women, one with 20 athletes and another with 20 healthy non-athletes. The electrocardiographic parameters of ventricular repolarization were compared between both groups.

Results
Mean age was 22.45±5.30 years vs. 22.45±5.30 years; $p > 0.05$. Weight was greater in athletes compared to non-athletes (69.63±7.73 kg vs. 51.20±6.63 kg; $p < 0.001$). Mean duration of sporting practice was 13.5 years. There were no significant differences in QTc and JTc intervals in lead DII between both groups, yet the intervals measured in lead V5 were longer in athletes (QTc: 405 ms vs. 424 ms; $p < 0.05$ - JTc: 307 ms vs. 329 ms; $p < 0.05$). QT interval dispersion was greater in athletes compared to non-athletes (74 ms vs. 43 ms; $p < 0.001$). Tpeak-Tend interval was greater in athletes in leads V1 (64 ms vs. 81 ms; $p < 0.05$), V3 (78 ms vs. 92 ms; $p < 0.05$), V4 (72 ms vs. 83 ms; $p < 0.05$) and V5 (63 ms vs. 80 ms; $p < 0.05$).

Conclusions
QTc and JTc intervals and QT interval dispersion were significantly greater in water polo athletes. Tpeak-Tend interval was significantly longer in leads V1, V3, V4 and V5 in the athlete group. Finally, although this group showed greater Tpeak-Tend interval dispersion, it was not statistically significant.

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Key words > Sports - Cardiology – Electrophysiology

Abbreviations >

CECG	Electrocardiogram	**Tp-Te**	Tpeak-Tend interval
QTd	QT interval dispersion	**Tp-Tfd**	Tpeak-Tend interval dispersion

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Water polo physiology has been difficult to study due to its characteristics in the field of play. Most of the energy required in this sport to sustain moderate to high intensity activities is provided by aerobic metabolism. However, these athletes may accumulate from moderate to very high levels of lactate following maximum effort, suggesting that anaerobic power and capacity is important and might be involved in short-term activities. (1) Less is known about cardiac electrophysiology in these athletes, especially in women. In a Holter study comparing 18 water polo players from the National Greek team with 15 controls, the former presented day and night sinus bradycardia , respiratory arrhythmia, (83% vs. 40%), sinus pauses (39% vs. 40%), occasional arrhythmia and conduction anomalies. (2)

The city of Villa Clara, Cuba is the training seat of the Female National Water Polo Pre-selection team, formed by top-level competitive athletes with the highest training loads. The purpose of this study was to investigate ventricular repolarization in this type of athletes, analyzing different electrocardiographic variables.

METHODS

A cross-sectional study was performed at the Cardiology Center "Ernesto Che Guevara" in Santa Clara, Cuba, in association with the Provincial Sports Medicine Center, between November 2008 and November 2009. Forty females with ages ranging from 15-32 years entered the study and were classified in two groups: 20 high performance athletes belonging to the national water polo team (study group) and 20 healthy non athletes (control group).

Women in the control group were selected by planned sampling to ensure the homogeneity of sampling age. The following inclusion and exclusion criteria were taken into account during the selection process:

Inclusion criteria

- Age between 15 and 32 years old.
- Classification as healthy or assumed as healthy in her health area
- Normal cardiovascular physical exam
- Normal echocardiographic and electrocardiographic exams.

Exclusion criteria

- Intake of any drug 72 h prior to the study
- Family history of sudden death in close relatives less than 40 years of age.

Simultaneous electrocardiographic leads were recorded in A CARDIOCID BB electrocardiograph made in Cuba, calibrated at a speed of 25 mm/s and a voltage of 10 mm/mV. A 12-lead ECG was performed with the subject in the supine position. Electrocardiographic measurements were done manually by two observers and expressed as their mean value. When there was a discrepancy $\geq$ 20 ms between the two observations, the measurement was discarded.

Electrocardiographic variables

- JT interval: is the time from the end of the QRS complex to the end of the T wave, expressed in milliseconds. It was measured in DII and V5 leads.
- QT interval: is the time from the onset of the QRS complex to the end of the T wave, expressed in milliseconds. It was measured in DII and V5 leads.
- Correction for heart rate (subindex c): this concept was applied to JT and QT intervals. It is calculated dividing the ECG variable by $\sqrt{\text{R-R}}$ (R-R: time interval between two peak R waves (i.e. peak R of the cardiac cycle to be corrected and peak R of the preceding beat).
- QT interval dispersion (QTd): is the time difference between the longest and shortest QT interval of the 12 ECG leads, expressed in milliseconds.
- Tpeak-Tend (Tp-Te): is the time from the peak to the end of the T wave, expressed in milliseconds. It was measured only in precordial leads.
- Tpeak-Tend dispersion (Tp-Ted): is the time difference between the longest and shortest Tp-Te in precordial leads, expressed in milliseconds.

Age, weight and electrocardiographic measurements were compared between the athlete and control groups.

Statistical analysis

SPSS 11.0 software for Windows was used for statistical analysis. Results were expressed as mean ± standard deviation (SD). Student t test was used to compare means of independent samples. Results were considered to be statistically significant for $p < 0.05$. Higher levels of significance were considered for $p < 0.01$ and $p < 0.001$.

RESULTS

General sample characteristics

There were no significant differences between the age of both groups (22.45 ± 5.30 years vs. 22.45 ± 5.30 years: $p > 0.05$). However, weight was significantly greater in athletes (69.63 ± 7.73 kg) compared to the control group (51.20 ± 6.63 kg). The mean duration of sporting practice in the athlete group was 13.5 years (Table 1).

Heart rate

Heart rate was significantly lower in the athlete group compared to the control group (83 bpm vs. 63 bpm).

Characteristics of ventricular repolarization

Table 2 shows that there were no significant differences in DII QTc and JTc intervals in the studied groups. However, the athlete group showed a significantly longer QTc (405 ms vs. 424 ms) and JTc (307 ms vs. 329 ms) in V5. Also, QTd was significantly greater in the athlete group compared to that in the control group (74 ms vs. 43 ms; $p < 0.001$).

Table 3 shows that the Tp-Te interval was more prolonged in the athlete group in leads V1 (64 ms vs. 81 ms), V3 (78 ms vs. 92 ms), V4 (72 ms vs. 83 ms) and V5 (63 ms vs. 80 ms). However, no significant differences were found between the studied groups in leads V2 and V6, nor in Tp-Ted, though this parameter exhibited higher values in the athlete group (31 ± 16.51 ms vs. 41 ± 18.89 ms; $p > 0.05$).

DISCUSSION

Different resting ECG studies in athletes have detected sinus bradycardia among other anomalies. (3,4) In resistance athletes, heart rates of 40-50 beats per minute and even lower have been reported.

In pairs of twins with discordant physical activity levels, Mutikainen et al found that a physically active lifestyle during a period of more than 30 years reduced resting heart rate. (5) In another study, 24 hour Holter monitoring revealed sinus bradycardia in 100% of cases. (6) In the present study, heart rates of up to 44 and 45 beats per minute were recorded.

Some authors suggest that repolarization anomalies in the ECG of trained athletes may be the initial manifestation of a latent structural heart disease that takes years to become manifest. (7) Contradictory findings published on QTc interval duration may have a direct relationship with the type of analyzed sport, the training methods and, possibly, the measurement techniques of electrocardiographic variables. Kasikcioglu et al found that the maximal QTc interval was significantly shorter in 122 professional Caucasian football players than in 103 control sedentary subjects (413.9 ms vs. 445.3 ms; $p < 0.001$) and a similar result was obtained for the minimal QTc (380.5 ms vs. 409.5 ms; $p < 0.005$). (8)

Recently, prolonged QTc interval was detected in long distance runners over 50 years of age immediately after finishing the physical activity and this anomaly persisted for one day (9). However, the age ranges in this study differed substantially from those presented here. In another study with subject ages similar to the ones included in this research, Heinz et al found no significant differences in the QTc interval of German Olympic swimmers of both sexes compared with healthy controls. (10) Peidro, in a review of the athlete's heart postulates that although the QT interval may be longer in athletes, this difference disappears when QTc is evaluated. (11)

QTd has been proposed as a predictor of ventricular arrhythmias. Studies performed both in animals (12) and humans (13) have supported this observation. Still, other authors have suggested that QTd is an approximate measurement of any repolarization abnormality (14, 15). Although QTd assessment has been an attempt to differentiate homogeneous from heterogeneous myocardium, this idea is not supported by all authors. (16) Normal QTd values are at present under debate. In a study performed in 5.812 apparently healthy subjects, those with QTd greater than 60 ms had twice the risk of sudden death. (17) Another similar study in 3455 subjects showed that those with QTd ≥ 80 ms vs. QTd< 30 ms had a fourfold higher risk of sudden death. (18) In the athlete group QTd reached values of 74 ms, above the prolonged QTd currently established by many authors. MacFarlane recommends 50 ms as the upper normal limit that may be moderately sensitive and specific and acknowledges that 80 ms is a clearly abnormal value with greater specificity. (19)

A study in elite athletes with physiological left ventricular hypertrophy did not reveal QTd anomalies. (20) Kasikcioglu et al found no significant differences ($p = 0.95$) in QTd of professional football players (33.2 ms) compared with sedentary controls (33.0 ms) using the manual method of ECG measurement employed here. (8) Also, Turkmen et al found no differences in the QTd of athletes and controls. (21)

As reflected in these studies, high performance

Variables	Non athletes n = 20	Athletes n = 20	p values
Duration of sporting practice (years)	_	13,50 ± 5,66	_
Chronological age (years)	22,45 ± 5,30	22,45 ± 5,30	p > 0,05
Weight (kg)	51,20 ± 6,63	69,63 ± 7,73	p < 0,001

Values are expressed as mean ± standard deviation.

Table 1. Body weight, chronological age and duration of sporting practice in the studied groups

Variables (ms)	Non athletes n = 20	Athletes n = 20	p values
QTc DII	410 ± 30,07	408 ± 26,67	p > 0,05
QTc V5	405 ± 17,13	424 ± 17,62	p < 0,05
JTc DII	326 ± 32,20	313 ± 19,44	p > 0,05
JTc V5	307 ± 23,40	329 ± 23,39	p < 0,05

Values are expressed as mean ± standard deviation.

Table 2. QTc y JTc intervals in the studied groups

Variables (ms)	Non athletes n = 20	Athletes n = 20	p values
Tp-Te V1	64 ± 13,92	81 ± 31,44	p < 0,05
Tp-Te V2	71 ± 19,97	79 ± 15,18	p > 0,05
Tp-Te V3	78 ± 24,19	92 ±17,65	p < 0,05
Tp-Te V4	72 ± 11,96	83 ± 16,25	p < 0,05
Tp-Te V5	63 ± 11,74	80 ± 12,98	p < 0,001
Tp-Te V6	68 ± 13,61	74 ± 14,65	p > 0,05
Tp-Ted	31 ± 16,51	41 ± 18,89	p > 0,05

Values are expressed as mean ± standard deviation.

Table 3. Tpeak-Tend interval and its dispersion (Tp-Ted) in precordial leads in the studied groups

sport does not normally produce different behaviours in QTc y QTd intervals than those observed in similar control sedentary subjects. However, the performance of these variables has not been described in elite female water polo players.

Changes in Tp-Te may reflect changes in transmural dispersion of ventricular repolarization and may be a predictor of arrhythmia risk in different pathologies. (22, 23). In long distance runners (30 km) over 50 years of age, an increase in QTc interval duration at the expense of Tp-Te interval prolongation was reported. (9)

We do not know the physiological and physiopathological significance of ventricular repolarization anomalies found in our study; however, they clearly differentiate water polo players from non athlete subjects.

A long-term follow-up of the subjects included in this study is required to draw final conclusions because although most analyzed variables have been useful to predict arrhythmogenesis in the context of cardiac diseases such as myocardial infarction, in high performance sport practice the context is quite a different and electrocardiographic changes might be attributed to the athlete heart.

The present study describes for the first time novel and classical ECG variables in elite female water polo.

Limitations

No longitudinal studies were performed to define the physiological and pathophysiological significance of these findings. In addition, no gender comparisons were made and the control number was small.

CONCLUSIONS

QTc, JTc and QTd intervals were significantly greater in the athlete group. Similarly, the Tp-Te interval was significantly longer in V1, V3, V4 and V5 leads in water polo athletes. Finally, although Tp-Ted was greater in this group, it was not statistically significant.

RESUMEN

Análisis de los intervalos QT, JT y Tpico-Tfinal y sus dispersiones en practicantes femeninas de polo acuático de élite

Introducción

La fisiología del polo acuático ha resultado difícil de estudiar debido a sus características en el campo de juego y la electrofisiología cardíaca de estos deportistas se conoce poco, menos aún en las mujeres. La electrocardiografía del polo acuático femenino de élite se ha estudiado escasamente.

Objetivo

Analizar la repolarización ventricular en mujeres practicantes de polo acuático de la Preselección Nacional de Cuba.

Material y métodos

Estudio transversal en una muestra conformada por dos grupos de mujeres: uno de 20 deportistas y otro de 20 personas sanas no deportistas, que se compararon respecto de parámetros electrocardiográficos de repolarización ventricular.

Resultados

La media de edad fue de 22,45 ± 5,30 años vs. 22,45 ± 5,30 años; p > 0,05. El peso fue mayor en las deportistas (69,63 ± 7,73 kg vs. 51,20 ± 6,63 kg; p < 0,001). La media de edad deportiva fue de 13,5 años. No existieron diferencias significativas del QTc y el JTc en la derivación DII entre ambos grupos, pero fueron mayores en las deportistas en la derivación V5 (QTc: 405 ms vs. 424 ms; p < 0,05 - JTc: 307 ms vs. 329 ms; p < 0,05). La dispersión del intervalo QT fue mayor en las deportistas que en las controles (74 ms vs. 43 ms; p < 0,001), el intervalo Tpico-Tfinal (Tpeak-Tend) alcanzó valores superiores en las deportistas en las derivaciones V1 (64 ms vs. 81 ms; p < 0,05), V3 (78 ms vs. 92 ms; p < 0,05), V4 (72 ms vs. 83 ms; p < 0,05) y V5 (63 ms vs. 80 ms; p <

Conclusión

Los intervalos QTc y JTc y la dispersión del QT fueron significativamente mayores en las deportistas. El intervalo Tpico-Tfinal fue significativamente mayor en las derivaciones V1, V3, V4 y V5 en las deportistas; la dispersión del intervalo Tpico-Tfinal fue superior en las deportistas, pero no estadísticamente significativo.

Palabras clave > Deportes - Cardiología - Electrofisiología

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