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ORIGINAL RESEARCH

Prevalence of Brugada-type ECG pattern and early ventricular repolarization pattern in Tunisian athletes

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Introduction: No data regarding the prevalence of the Brugada-type electrocardiogram (ECG) pattern and the early ventricular repolarization pattern (ERP) in the North African population were available. The aims of this study were to determine the frequency of Brugada-type ECG pattern and ERP in Tunisia and to evaluate ECG descriptors of ventricular repolarization in a population of athletes.

Methods: Over a 2-year period, resting 12-lead ECG recordings were analyzed from athletes (n = 540; 348 males; age 18.3 ± 2.4 years). Brugada-type ECG pattern was defined as Type 1, 2, or 3, and ERP was characterized by an elevation of the J point in the inferior and/or lateral leads. The population was divided into three groups of athletes: ERP group; Brugada-type ECG pattern group; and control group, with neither ERP nor Brugada ECG pattern. Clinical and electrocardiographic parameters were compared among the study groups.

Results: Nine subjects (1.66%) had a Brugada-type ECG pattern. None of them had the coved-type, 3 (0.6%) had the Type 2, and 6 (1.1%) had the Type 3. All subjects were asymptomatic. A Brugada-type ECG pattern was observed in seven males. No female had the Type 2 Brugada ECG pattern. ECG parameters were similar among Brugada-type ECG pattern and control athletes. ERP (119 subjects, 22%) was obtained in 98 males. Heart rate was lower, the QRS duration shorter and QT and $T_{peak}–T_{end}$ intervals were longer in ERP than control groups.

Conclusion: The results indicate that the frequency of the Brugada-type ECG pattern and ERP were respectively 1.66% and 22.00% in athletes, being more prevalent in males. The ERP group experienced shorter QRS duration and longer $T_{peak}–T_{end}$ interval than in the control population.

Keywords: J wave, ERP athletes, T wave

Introduction

The J wave is a deflection immediately following the QRS complex of the surface electrocardiogram (ECG). When partially buried in the R wave, the J wave appears as J-point elevation or ST-segment elevation. Renewed interest in early repolarization arose after the discovery of an associated high risk of sudden cardiac death by ventricular fibrillation with both ST elevation in right precordial (V1–V3)[1,2] and early repolarization in the inferior or mid to lateral precordial leads.[3–5]

Conflicting evidence exists on prevalence and prognostic significance of the Brugada-type ECG pattern and early ventricular repolarization pattern (ERP), particularly when found by chance in an asymptomatic individual and in an ethnic population where epidemiological data are lacking. To our knowledge, no data regarding the prevalence of the Brugada-type ECG pattern and the ERP exist in the North African population.

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The aim of this study was to determine the frequencies of the Brugada-type ECG pattern and ERP and to evaluate ECG descriptors of ventricular repolarization in a population of Tunisian athletes.

Methods

Subjects

Over a 2-year period (2008–2009), resting 12-lead ECG recordings were analyzed from athletes (n = 540; 348 males; 100% white Arabs, aged 18.3 ± 2.4 years, height = 172 ± 12 cm, weight = 63.6 ± 12.3 kg) as part of their physical examination. They were routinely controlled in the Central Sports Medicine Centre of El Menzah in Tunisia. The studied athletes represented 14 disciplines. All those who entered this study had no evidence of organic heart disease as judged from clinical history and physical and echocardiographic examination.

A 12-lead ECG (at a paper speed of 25 mm/s and 1 mV/10 mm standard gain) was recorded from each subject with the same equipment by the same person.

Brugada-type ECG pattern was defined as Type 1, 2, or 3. The consensus report of the Study Group of the Molecular Basis of Arrhythmias laid down precise diagnostic criteria for the Brugada-type ECG pattern,[6,7] recognizing three variants of the repolarization pattern in chest leads V1–V3 (Type 1, classical convex ST elevation of ≥2 mm; Type 2, J wave amplitude ≥2 mm with concave ST elevation ≥1 mm; and Type 3, J point elevation with the ST segment isoelectric or elevated by <1 mm).

ERP was defined as elevation of the J point (QRS-ST junction) noted as either QRS slurring or notching ≥0.1 mV in more than two adjacent leads in the inferior leads (II, III, and aVF) and/or lateral leads (I, aVL, and V_4 through V_6).[3]

PR intervals, P wave duration and amplitude, T wave amplitude, and QRS amplitude were measured on lead II. P wave, T wave and QRS axis were calculated from frontal leads. The maximum QRS duration was assessed in any of the measurable leads of each ECG. Mean RR interval was also measured.

The interval from the peak to the end of the T wave (T_{peak}–T_{end}) and the QT interval were measured on leads V2 or V3 and leads II or V5. The point of T wave offset was defined as the return to the baseline. T_{peak}–T_{end}/QT ratio was also calculated.

QT intervals were corrected for heart rate using Fridericia's [QTc Fri = $QT(RR)^{-1/3}$] and Sagie-Framingham's [QTcFr = QT + 0.154 (1000 − RR)] formulas.[8,9]

All ECG measurements were performed separately by two independent investigators who were blinded to the clinical data of the patients. The interpreters of the ECGs assessed also Brugada-type ECG patterns and ERP simultaneously. The averages of the measurements of the two observers were used for comparisons. The diagnosis of Brugada-type ECG pattern or ERP was made only when both investigators agreed on the classification of the ECG abnormalities.

The population was subsequently divided into three groups: ERP group; Brugada-type ECG pattern group; and control subjects, without either ERP or Brugada type ECG pattern. Clinical and ECG parameters were described for each group and compared with control groups.

Statistical analysis

The age, gender, and ECG findings of the cases were recorded with SPSS (version 12.0, SPSS, Inc, Chicago, IL). Values are expressed as the mean ± SD (standard deviation), n value, and percentage (%). Student's *t*-test for independent samples and the chi-squared test were used, when appropriate, comparing two different groups. Two-sided $P < 0.05$ was considered significant. The study protocol was approved by the Ethics Committee of the Central Sports Medicine Centre of El Menzah in Tunisia.

Results

Prevalence of the Brugada-type ECG pattern

Among 540 athletes, we found nine subjects (1.66%) with a Brugada-type ECG pattern. All the subjects with the Brugada-type ECG pattern had a saddleback-type ECG abnormality and were asymptomatic. Three (0.6%) had the Type 2 (Figure 1), and six (1.1%) had the Type 3. A Brugada-type ECG pattern was obtained in two females and in seven males. No female had the Type 2, and none of the athletes displayed both ERP and Brugada-type ECG pattern.

The mean age, mean body area, and mean systemic arterial pressure in Brugada-type ECG pattern athletes were respectively 19.3 ± 1.0 years, 1.77 ± 0.16 m^2, and 120 ± 18/74 ± 9 mmHg, that were similar to clinical control parameters. However, males are more prevalent in Brugada-type ECG pattern than control athletes (77.7% versus 58.9%; $P < 0.0001$). Mean ECG parameters are summarized in Table 1. Heart rate, PR interval, P wave duration and amplitude, T wave, P wave, QRS axis, QRS duration,

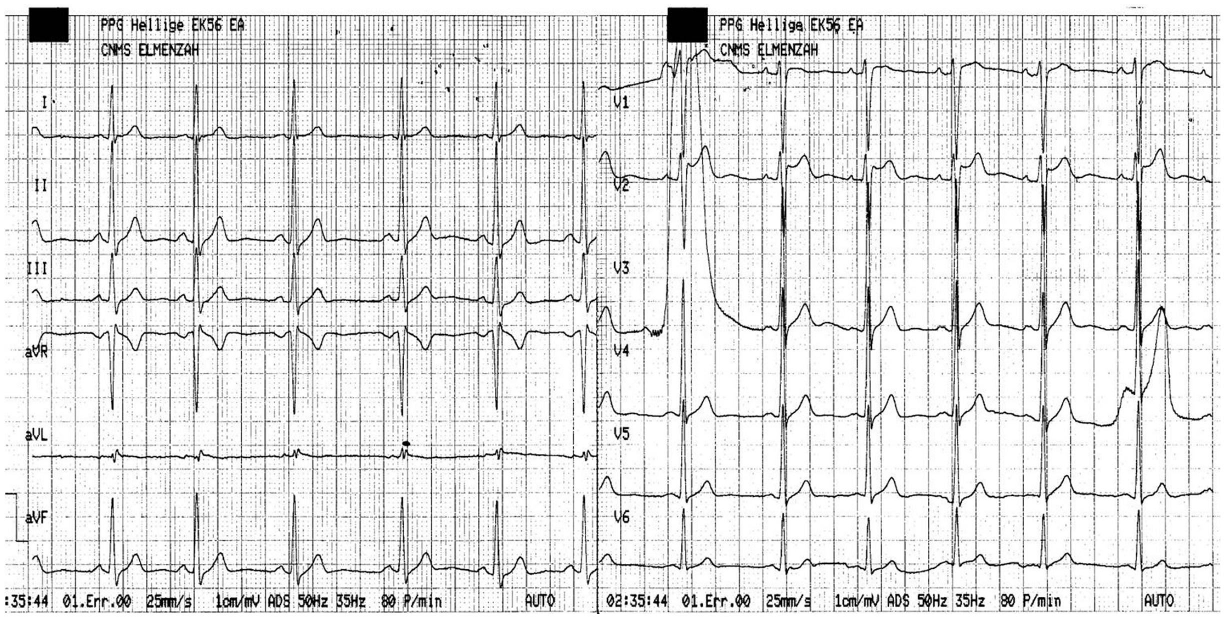

Figure 1 Type 2 Brugada-type ECG of an athlete demonstrates saddle-back type ST-segment elevation (>1 mm) in lead V2.

Table 1 Clinical and ECG parameters of study cohorts

Parameter	ERP group	Control group	Brugada-type ECG pattern group	*P*[a]
N (%)	119 (22%)	412 (76.3%)	9 (1.7%)	
Male gender (N, %)	98, 82.3%	243, 58.9%	7, 77.7%	0.000
Age (years)	18.2 ± 2.3	18.1 ± 2.9	19.3 ± 1	0.6
Body area (m²)	1.78 ± 0.23	1.72 ± 0.19	1.77 ± 0.16	0.009
Weight (kg)	66.7 ± 12.4	62.7 ± 12.1	65 ± 9.9	0.002
Height (cm)	172.7 ± 19	171.6 ± 9	174.1 ± 7.9	0.375
Systolic BP (mmHg)	116 ± 12	115 ± 11	120 ± 18	0.81
Diastolic BP (mmHg)	70 ± 9	68 ± 10	74 ± 9	0.136
RR (ms)	867 ± 157	781 ± 145	815 ± 218	0.000
PR interval (ms)	143 ± 16	143 ± 21	145 ± 13	0.76
QRS interval (ms)	86 ± 10	89 ± 11	90 ± 13	0.005
QRS axis (°)	68 ± 25	67 ± 27	58 ± 26	0.9
T axis (°)	58 ± 18	55 ± 20	56 ± 7.5	0.19
P axis (°)	56 ± 25	56 ± 26	65 ± 10	0.97
P wave duration (ms)	94 ± 12	94 ± 12	98 ± 10	0.8
QRS amplitude DII (mV)	1.6 ± 0.4	1.4 ± 0.4	1.4 ± 0.7	0.000
P wave amplitude DII (mV)	0.14 ± 0.05	0.15 ± 0.05	0.160.04	0.2
T wave amplitude DII (mV)	0.48 ± 0.17	0.39 ± 0.18	0.32 ± 0.11	0.000
QT interval DII or V5 (ms)	389 ± 48	370 ± 27	366 ± 40	0.000
QT interval V2 or V3 (ms)	383 ± 38	370 ± 35	367 ± 37	0.001
Fridericia c-QT DII or V5 (ms)	405 ± 20	405 ± 27	394 ± 31	0.9
Fridericia c-QT V2 or V3 (ms)	403 ± 35	405 ± 37	396 ± 24	0.6
Framingham c-QT DII or V5 (ms)	405 ± 20	405 ± 27	394 ± 28	0.6
Framingham c-QT V2 or V3 (ms)	404 ± 33	404 ± 31	396 ± 24	0.8
T_{peak}-T_{end} DII or V5 (ms)	88 ± 9	85 ± 10	82 ± 12	0.007
T_{peak}-T_{end} V2 or V3 (ms)	103 ± 14	97 ± 14	95 ± 12	0.000
T_{peak}-T_{end}/QT V2 or V3 ratio	0.26 ± 0.03	0.26 ± 0.07	0.25 ± 0.03	0.8
T_{peak}-T_{end}/QT DII or V5 ratio	0.22 ± 0.02	0.23 ± 0.02	0.22 ± 0.02	0.4

Note: [a]*P* value calculated between ERP group and control group.

Abbreviations: BP, blood pressure; c-QT, corrected QT interval; ECG, electrocardiogram; ERP, early repolarization pattern.

QT intervals, corrected QT intervals, T_{peak}–T_{end} intervals and T_{peak}–T_{end}/QT ratio in Brugada-type ECG pattern group were not statistically different among control athletes.

Prevalence of early ventricular repolarization pattern

A total of 119 ECGs (22%) were found to fulfill the criteria for ERP that was obtained in 98 males and in 21 females. Males are more prevalent in ERP than in control group (82.3% versus 58.9%; $P < 0.0001$).

ERP was present in the inferior leads (II, III, aVF) in 37 patients (31.1%), in the lateral leads (I, aVL, V_4–V_6) in 71 patients (59.6%), and in both the inferior and lateral leads in 11 patients (9.2%) (Figures 2A and 2B).

Weight and body area were significant, although only marginally higher in ERP athletes than in controls. Mean age, mean height, and systolic and diastolic blood pressure were similar between the two groups.

PR interval, P wave duration and amplitude, QRS, P wave, and T wave axis were similar between ERP group

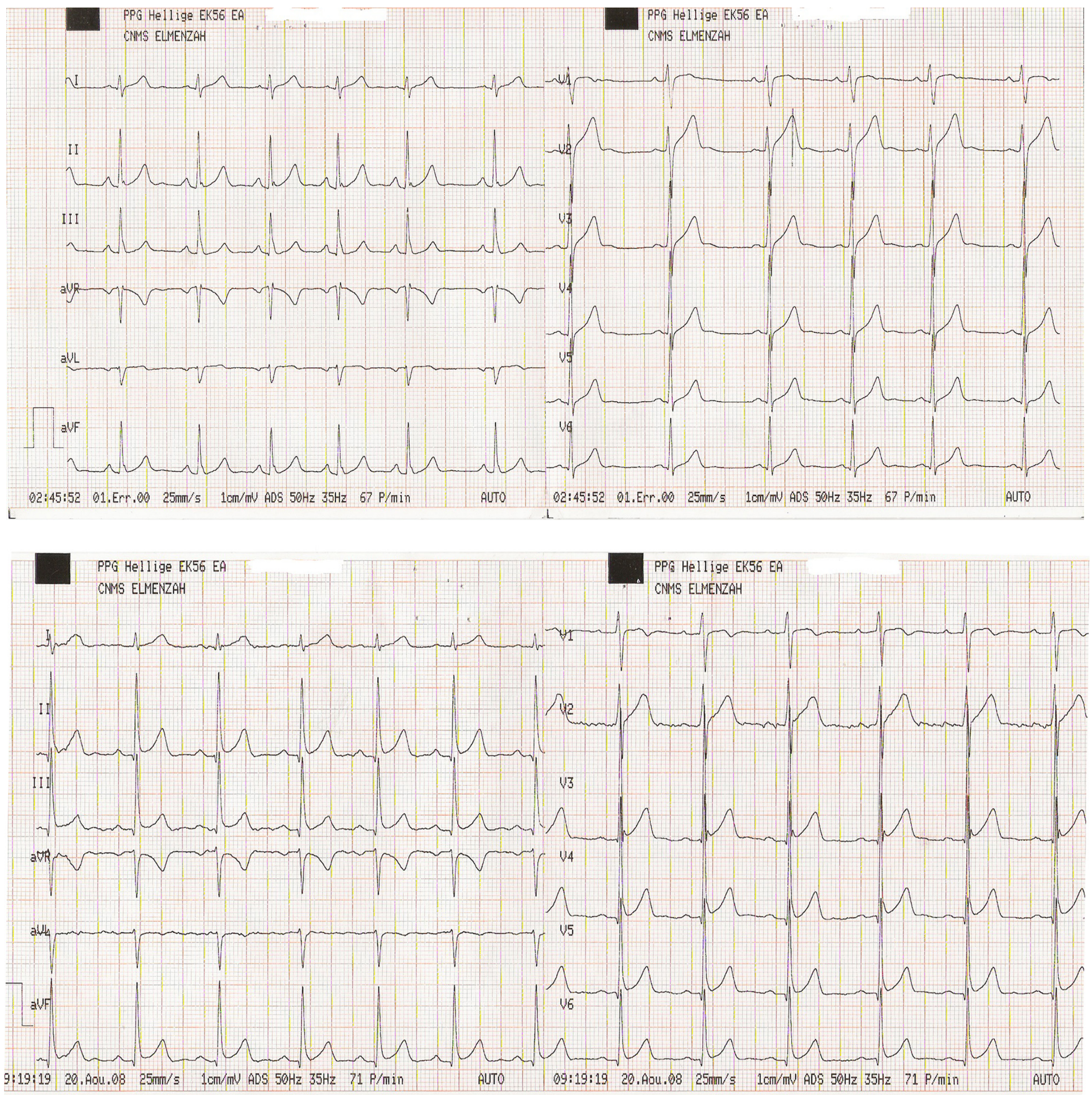

Figure 2 Sample electrocardiograms from two athletes, demonstrating early ventricular repolarization (ERP)-type ECG. ERP defined as ≥1 mm elevation of the QRS–ST junction (J point) in either inferior leads (Type 2) (**A**) or inferior and lateral leads (Type 3) (**B**).

and controls. ERP athletes had lower heart rate, greater QRS and T wave amplitude, and a slightly but significantly shorter QRS duration than the controls.

The duration of the QT interval was longer in ERP athletes than in control athletes, but no difference was observed when the QT interval was corrected for heart rate (Table 1). T_{peak}–T_{end} intervals were longer in the ERP athletes than in control athletes. However, T_{peak}–T_{end}/QT ratio was not different between the two groups (Table 1).

Discussion

The frequency of Brugada-type ECG pattern and ERP were found to differ among ethnic groups. No data regarding the frequency of the J wave sign exist in North African populations.

Brugada-type ECG pattern

Our results indicate that the frequency of the Brugada-type ECG pattern was 1.66% in athletes, with a saddleback-type ECG abnormality in all cases. Epidemiological data suggest that Brugada-type ECG pattern is ubiquitous, but it varies significantly among ethnic populations, higher in south-eastern Asian countries, an event possibly reflecting the geographical genetic distribution of the disease.[6,10] Large epidemiological information has been reported from Asian,[11–21] European,[22–30] and American[31–34] populations, and the data available are difficult to compare because of differences in the diagnostic criteria applied, and differences in the characteristics of the populations selected (sex ratio, age, healthy subjects or tertiary hospital patients) (Table 2).

In accordance with different studies,[23,25,30] we did not document any person with Brugada Type 1 ECG pattern.

Considering the dynamic nature of the ECG features, the true incidence of Brugada-type ECG pattern might have been underestimated.[29]

Only one previous study had evaluated the prevalence of Brugada-type ECG pattern in an athletic cohort of 155 males with a reported prevalence of 7.7%, with a Brugada Type 1 ECG pattern in all cases.[24]

The disparities between the present study and the Bianco et al study[24] may be explained by differences between the two study populations. Bianco et al have included only males, older (mean age of the population: 30.9 ± 10.1 years), and competitive athletes.[24]

In southern Europe, Hermida et al[22] found a high prevalence of concave ST-segment elevation in 1000 European men (6%) and a far lower prevalence of convex ST-segment elevation (0.1%). Monroe and Littman[31] found 52 cases of the Brugada-type ECG among approximately 12,000 unselected noncardiac hospitalized patients. In their report, the convex pattern was present in only two cases. In adolescents and in school children, the frequency of Brugada-type ECG pattern was very low even in regions of Southeast Asia where the Brugada syndrome is endemic.[14–16] Yamakawa et al[14] have demonstrated a tendency for the prevalence of Brugada-type ECG pattern to increase with age. In the present study, we did not evaluate the prognostic value of Brugada type ECG pattern. Previous studies have suggested that Brugada-type ECG pattern has a benign natural course, independent of the ethnic origin of the study population.[12,20,21,28,29]

ERP

Of our healthy "young athletes", 22% had J-point elevation, a figure consistent with the 22%[35] to 27%[37] of young athletes with J-point elevation reported by others.[35–37] Bianco et al[24] identified a higher ERP prevalence (89%) in their competitive athlete group (age 30.9 ± 10.1 years). The athletes included in our study and those described by Rosso et al[35] were noncompetitive.

The ERP has long been considered to be a "benign" ECG manifestation that is seen more commonly in young healthy men and athletes.[37–40] No athletes with ERP, reported by Bianco et al[24] had suffered from major ventricular arrhythmias from the time of the study (2001) onward to 2009.[40] However, mounting evidence suggests that the ERP may be associated with a risk for ventricular fibrillation, depending on the location of ERP, magnitude of the J wave, and degree of ST elevation.[3–5,41,42]

Recently, Sinner et al[42] have reported a high prevalence of ERP (13.1%) in a population-based cohort of middle-aged individuals (35–74 years). After a mean follow-up of 18.9 years, ERP was associated with about a 2–4-fold increased risk of cardiac mortality in individuals between 35 and 54 years. An inferior localization of ERP was associated with a particularly increased risk.[42]

Heart rate was found to be lower in ERP subjects than in controls, as previously reported.[24,37,43,44] A greater vagotonia in ERP subjects has been previously reported as a possible contributing factor.[37,43] The distribution of J-point elevation in our study was similar to that described by Rosso et al.[35] Athletes had more commonly J-point elevation in lateral leads (V4–V6, Type 1) than in the inferior leads (Type 2).

The QRS duration was significantly shorter in ERP athletes than in controls. This is in accordance with previ-

Table 2 Comparison of the prevalence of Brugada-type ECG in different ethnic populations

Study	Year of publication	Origin	N	Males (%)	Age (years)	Nature of population	Sex ratio of BS M/F	Prevalence of BS Type I (%)	Prevalence of all BS types (%)	FU	Sudden death during FU
Asian population											
Furuhashi et al[11]	2001	Japan	8612	69.5	49.2 (22–84)	Health examination	11/1	0.05	0.14	NA	NA
Mastuo et al[12]	2001	Japan	4788	40.8	45 ± 10.5	Health examination	27/5	NA	0.14	41 years	5
Atarashi et al[13]	2001	Japan	10,000	89.1	42 ± 9	Health examination	16/0	NA	0.16	NA	NA
Yamakawa et al[14]	2004	Japan	20,387	51.1	9.7 ± 3.2	School children	1/1	0.0049	0.0098	NA	NA
Yoshinaga et al[15]	2004	Japan	7022	100	15	Male adolescents	7	0.06	0.1	NA	NA
Oe et al[16]	2005	Japan	21,944	41.4	6–7	Children, CBP	2/2	0.005	0.02	6.8 ± 1 years	0
Babaee Bigi et al[17]	2007	Iran	3895	46	38.2 ± 11.9	Tertiary hospital	66/44	0.54	2.56	NA	NA
Gervacio-Domingo et al[18]	2008	Philippines	3907	NA	≥20	Healthy subjects	68/26	0.2	2.1	NA	NA
Wajed et al[19]	2008	Pakistan	1100	64.7	NA	Healthy young students	7/2	NA	0.8	NA	NA
Tsuji et al[20]	2008	Japan	13,904	26	58 ± 10	Health examination	80/18	0.26	0.7	7.8 ± 1.6 years	1
Sidik et al[21]	2009	China Singapore	392	55.9	49.9 ± 19.1	Tertiary medical center	27/1	4.8	7.1	30.4 person-years	0
European population											
Hermida et al[22]	2000	France	1000	63.2	39 ± 10	Normal subjects	52/9	0.1	0.61	49 ± 30 months	0
Viskin et al[23]	2000	Israel	592	58.4	36 ± 10	Tertiary hospital	NA	0	1	NA	NA
Bianco et al[24]	2001	Italy	155	100%	30.9 ± 10.1	Competitive athletes	12	7.7	NA	NA	NA
Junttila et al[25]	2004	Finland	2749	100%	18–30	Finnish air force	NA	0	0.61	19 ± 2 years	0
Blangy et al[26]	2005	France	35,309	47%	37.2	Health examination	14/6	0.016	0.05	30 months	0
Bozkurt et al[27]	2006	Turkey	1238	77.8%	38.9 ± 17.6	Tertiary hospital and university students	5/1	0.08	0.48	NA	NA
Letsas et al[28]	2007	Greece	11,488	57.7%	15–98	Tertiary hospital	23/2	0.02	0.22	24 ± 12 months	0
Gallagher et al[29]	2008	Italy	12,012	90.8%	29 ± 9	Healthy subjects	23/0	0.016	0.19	10.1 ± 5.5 years	1 patient/0.3% per patient of year FU
Sinner et al[30]	2009	German	4149	49%	50.6 ± 13.9	General population	0	0	0	NA	NA
American population											
Monroe and Littman[31]	2000	USA	12,000	NA	NA	Urban teaching hospital	NA	0.016	0.43	NA	NA
Greer and Glancy[32]	2003	USA	27,328	NA	NA	Medical center	NA	0	0.065	NA	NA
Donohue and [33]	2008	USA	1348	NA	52.7 ± 16.2	Tertiary hospital	1/1	0	0.14	NA	NA
Patel et al[34]	2009	USA	162,590	NA	NA	Tertiary medical center	13/7	0.005	0.012	NA	NA
North African population											
This study	2010	Tunisia	540	348	18.3 ± 2.4	Athletes	7/2	0	1.16	NA	NA

Abbreviations: BS, Brugada sign; FU, follow-up; F, female; M, male; NA, not available; CBP, community-based population.

ously published data,[24] but discordant with the Dilaveris et al study.[44] Disparities may be explained by differences in the populations studied and possible differences in the level of physical conditioning.

In accordance with previous publications, mean QT duration was significantly higher in ERP athletes than in control athletes.[24,37,44] However, corrected QT intervals were similar between these two groups, which is in accordance with the Mehta and Jain study[37] but in contrast with other studies finding lower corrected QT in ERP subjects than in controls.[44] T_{peak}–T_{end} intervals were significantly higher in ERP than in control athletes. T_{peak}–T_{end}/QT ratio showed no difference between these two groups.

Study limitations

First, considering the dynamic nature of the ECG features, the true prevalence of Brugada-type ECG pattern and ERP might have been underestimated in this study. Second, we have identified differences in QT duration on leads V2 and II, which may be explained by differences in the projection of the T-wave loop between the ECG leads, or may simply be due to inaccuracies in defining the end of the T wave. Third, the physical activity level depending on the corresponding disciplines was not evaluated. Therefore, possible association between the presence of ERP and the athlete discipline was not investigated. Finally, no follow-up was described to ERP and Brugada-type ECG pattern, so no prognostic value of these ECG patterns were available.

Conclusion

The results indicate that the frequency of the Brugada-type ECG pattern and ERP were respectively 1.66% and 22% in athletes, being more prevalent in males. These results are similar to the findings of studies performed in European and American countries. ERP was associated with shorter QRS duration and longer T_{peak}–T_{end} interval. Further population-based investigation is warranted to determine the prognostic value of the J-point elevation.

Disclosure

The authors report no conflicts of interest in this work.

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