Advantages of Electrocardiographic Monitoring in Top Level Athletes

F. Carre* J. C. Chignon**

*Service des Explorations Fonctionnelles et Biologie du Sport, Professeur Le Bars, Hôpital Pontchaillou, 35033 Rennes Cedex, France
**Institut National des Sports, Vincennes, France

Abstract


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We used continuous electrocardiographic monitoring according to Holter's method for a tentative evaluation of the prognostic value of the main electrocardiographic peculiarities of the "athlete's heart". Five hundred and eighty-seven Holter recordings were performed in 164 top athletes divided into three groups: dynamic, static and mixed. Selection criteria were either clinical or electrical (resting-ECG). The prognostic value of arrhythmia is variable: unworrying junctional rhythm (JR) and auriculo-ventricular blocks (AVB) that disappeared under strain, which in our study interested mostly the dynamic group. No pejorative prognostic criteria were found related to supraventricular premature beats (SVPB). Ventricular premature beats (VPB) of recent occurrence were predominately found, in our study, in the static athletes; their occurrence was not always accounted for and their prognosis, at least as regards sports, was uncertain. Holters repeated throughout the sports season made it possible to establish a relationship between some peculiarities and the training intensiveness: auriculo-ventricular block and junction rhythm culminated during intensive periods. Unusual sinus tachycardia would be indicative of over-training.

Key words

Athlete's heart, Holter, ventricular premature beats

Introduction

Arrhythmia and electrocardiographic peculiarities in top-trained athletes are well-known (22, 27, 30, 32). Their detection may, however, put the subject's aptitude for top competition into question (27). The superiority of long-term electrocardiographic monitoring (LTE) on standard electrocardiogram (ECG) (16–36) as well as on effort ECG (29–36) for studying arrhythmia has been proven. We applied this technique to athletes who presented with either arrhythmia on standard ECG or clinical signs evocative of rhythm disorders, to try and assess the prognostic value of such arrhythmia and their possible correlation to training.

Methods

Population

One hundred and sixty-four athletes presenting some peculiarity on the resting ECG or functional symptoms were studied: 133 male, 31 female, mean age 24.6 ± 4.6 years. They were selected among the 2,000 (8.2%) top athletes followed up over two years by the National Institute of Sports.

Athletes were divided into 3 groups according to sports discipline:

Group 1: Dynamic (n = 84, mean age 22.8 ± 3 years)
Group 2: Static (n = 26, mean age 25.7 ± 2.5 years)
Group 3: Mixed (mostly team sports) (n = 54, mean age 23.9 ± 3.4 years)

Dynamic activities are characterized by an alternance of concentric and eccentric muscular contractions involving important muscular masses over a long period, whereas static activities are characterized by muscular contraction without any change in the muscle length, sometimes associated with apnea.

Selection criteria were either electrocardiographic or clinical (Fig. 1).

Electrocardiographic criteria

- Peculiarities of the sinus rhythm: bradycardia (≤ 45 bpm), sinus arrhythmia, unusual tachycardia (≥ 100 bpm).
- Junctional rhythms (JR).
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Fig. 1 Selection criteria for Holter monitoring, expressed as percentages (n).
A = Total population; B = Group 1; C = Group 2; D = Group 3.
1 = Bradycardia; 2 = Sinus arrhythmia; 3 = Rest tachycardia; 4 = J. R. 5a = First rate AVB; 5b = Second rate AVB; 5c = 1st and 2nd rate AVB.
6a = SVPB; 6b = VPB; 6c = SVPB + VPB; 7a = WPW; 7b = Short PR without delta wave.
8 = Clinical signs

Table 1 Frequency of SVPB over 24 hours

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<thead>
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<th>SVPB/24 hours</th>
<th>n = 26</th>
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Clinical criteria

Holter monitoring was called for in 19 subjects by functional symptoms indicative of arrhythmia (palpitations, dizzy spells during or after strenuous exercise) or unexplained loss of performance.

The recording apparatus was the 2-channel type Avionics. Mean recording duration was 22 hours and 24 minutes. At least one programmed training session was performed during each recording. Each magnetic tape was read twice by the same cardiologist according to the device automatic quantification program, and by systematic hard copy recording of a 10-second sequence every 10 minutes. This type of sampling provides precise computation of the percentage of junction complexes or AVB. A total of 587 recordings were analyzed. Repetition of graphs was justified either by the need to follow-up the disturbances (premature beats, WPW, functional signs, ...) after training modification, of even therapy introduction, or by the study of the peculiarity variations throughout the sporting season (up to 6 Holters in some cases: sinus bradycardia, JR, AVB.)

Results

Bradycardia and sinus arrhythmia: they were found only in some Group 1 or Group 3 subjects. Athletes with sinus bradycardia (n = 10) presented with a nocturnal increase of it (loss of 10 ± 5 heart beats.) Maximal theoretical heart rate (220-age ± 10 bpm) was always achieved during training. In the 7 cases of sinusarrhythmia investigated, it was always sporadic and culminated at night. No severe conduc- tion or rhythm anomalies were found in any one of these 17 subjects.

Junctional rhythms (JR)

They were found in 39 subjects, 31 from Group 1 (79.5%), in 6 from Group 3 (15.4%) and in 2 from Group 2 (5.1%). In all cases the type of junctional complex recorded was identical to that observed on basic ECG. This junctional rhythm was more frequent at night, its escapement frequency remained the same (55 to 65 according to subject), and always disappeared with heart rate increase. But in 6 cases (15%) it only disappeared totally beyond 120 bpm. Junctional rhythm disappeared during resting periods and reappeared upon training resumption, to be at a peak at competition time. This
JR was found isolated (69%) or associated with other arrhythmias (31%): SVPB, VPB, AVB1, Mobitz1, but we never observed any tachycardia.

**Auriculo-ventricular block:** Observed in 10 subjects from Group 1 and in 2 from Group 2, it was always the same type of AVB as that observed on the basic ECG: 3 AVB1, 4 Mobitz1, but the association of both was more frequent (5 cases against 2). No higher rate AVB was observed. AVB was more frequent during bradycardia periods, and especially at night, and heart rate increase beyond 80 bpm always made it disappear. Its occurring frequency varied in the course of the season (Fig. 2), decreasing or even disappearing completely (33% of cases) during the off-season, while it was always at a peak during intensive training periods, blocks even increasing (1 case). Neither functional symptoms nor arrhythmia were observed.

**Sinus tachycardia:** They were predominantly found in Group 3 subjects (n = 6; 54%). The mean frequency over 24 hours ranged from 72 to 94. No other arrhythmia was observed. Repeated LTE revealed the disappearance of tachycardia with the reduction of training intensiveness.

**Supraventricular premature beats (SVPB):** Their 24-hour incidence is shown in Table 1. They culminated outside of the bradycardia or training periods. Their frequency increased slightly during intensive training sessions. We did not observe any repetition phenomena or any paroxysmal atrial tachycardia. LTE did not reveal any more association with VPB than standard ECG did.

**Ventricular premature beats (VPB):** In 13 cases (36%) it was a long known extrasystole and in 23 cases (64%) a more recent dysrhythmia. Their respective characteristics, as recorded from LTE, are shown in Table 2. When the VPB was an old one, it usually disappeared under strain, and most often (n = 9; 69%) at a heart rate approaching 80 to 100 bpm. Conversely, recent VPB were persistent or increased under strain. When they did disappear, it was always with a heart rate in excess of 100 bpm (n = 10; 43%). They culminated during training sessions. The R/T phenomenon was scarce (n = 4), i.e. 11% of all PB cases; it was isolated over a 24-hour period, and was always observed during apneic exercise. VPB frequency over 24 hours was higher when the arrhythmia was recent, but the frequency was never below 100 per 24 hours.

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**Pre-excitation syndromes:** While no arrhythmia was observed in subjects with a short PR, out of the 6 WPW cases studied, on the contrary, 3 cases presented rhythm disturbances (50%): one auricular tachysystole, one VPB, and a case of reciprocal junctional tachycardia was recorded in a diver during apneic exercise. Two out of the other tree WPW disappeared suddenly under strain (130 and 142 bpm, respectively).

**The Holters** fitted to the subjects presenting functional symptoms revealed: In 3 cases (16%) three short spells of reciprocal junctional tachycardia in sportsmen with no WPW syndrome on their basic ECG. In one case (5%) major spells of sinus bradycardia, the most extreme of which was recorded at night, were measured at 21 bpm over 3 beats. Lastly, in one case a short nocturnal spell of ventricular tachycardia was evidenced.

**Discussion**

Earlier studies had assessed the frequency of arrhythmia in athletes, both from standard ECG (22, 30, 32) and LTE (14, 26, 29, 31, 34, 35). We used Holter monitoring in athletes with rhythmic disorders to try and assess the prognosis and establish any possible correlation to training. Since ECG peculiarities are interpreted as resulting from the combined sympathetic and parasympathetic influences (9, 11, 22, 24, 32), such as bradycardia and sinus arrhythmia, JR and low rate AVB are classically more frequently observed in dynamic type athletes (11, 13, 21, 32). This involved 68 subjects in our study, 51 from Group 1 (75%), and 15 from Group 3 (22%). On LTE, the incidence of JR and AVB culminated during bradycardia periods, but this association was not constant. There is a possible association of JR with AVB (25%). JR and AVB both always disappear under strain. Sometimes, JR disappear totally only at a heart rate over 120 bpm (n = 6; 15%). Their frequency may vary with the period of the sports season, hence with the type of training performed. No severe rhythmic disorder was observed. None of these 68 athletes complained about stagnating or reduced performance, which is indicative that none of these subjects were involved in a program of parasympathetic overtraining (20). In contrast, in a marathon specialist, who complained about lipothymia and stagnating performances, LTE revealed major bradycardia episodes. Reducing the amount of training sufficed to make these disorders recede. So, while the classically good prognosis of such ECG peculiarities in top-trained athletes (1, 9, 19, 24) has been confirmed by the present study, it is worth noting that some functional signs may be linked to excessively low heart rate. Other authors have reported cases of syncope in athletes with major bradycardia (10). In a regularly bradycardiac athlete, the occurrence of permanent sinus tachycardia should first evoke overtraining (20, 33), especially when reduced performance and intensive training are associated. In the 11 cases explored, LTE showed a mean 24-hour heart rate higher than that usually observed in athletes of the same level (34, 35). However, no severe rhythmic disorder was observed, and adjusting the training corrected the tachycardia.

Although the frequency of AVB over a 24-hour period was higher than that observed in sedentary subjects (2.3, 6), the absence of associated functional signs and severe ventricular or supraventricular rhythmic disorders confirmed
Lastly, exploring abnormal symptoms in athletes is a necessary endeavor. The role of diet in overtraining has been reported (7, 33). Secret diuretic intake may also account for these effects. In our experiment, modifying training did not always cancel premature beats. In fact, only a long-term cohort study over several years, as was done with sedentary subjects (17), might provide a better assessment of the long-term prognosis of this type of premature beats.

The discovery of a pre-excitation syndrome always poses the problem of sports practice ability. The advantages of LTE have already been shown in sedentary subjects (15, 25). The present study confirmed that some underlying arrhythmias may be disclosed by sports practice (2 cases) and the resulting modifications of the autonomous nervous system (18). Normalization of the ECG after suspending sports practice also favours this hypothesis. The intermittent characteristic, classically of favourable prognosis (18), of pre-excitation may be evidenced with LTE. Its sudden disappearance under strain, evocative of an anterograde, prolonged refractory period (21), can also be recorded on LTE. Any pre-excitation syndrome must be explored with LTE involved static athletes, as compared with 6 specialists from Group 1 and 5 from Group 3. A short episode of ventricular tachycardia (VT) was observed in a canoe specialist. Similar cases have been reported in sedentary subjects (2, 3, 35) or athletes (28, 31) who were apparently free of any cardiopathy. This was neither favoured by a R/T phenomenon (5), nor by an extended QT (28). Echocardiography was normal, and even if the classic benignity criteria (2, 36) were always present, this athlete presented with persistent extrasystole and prolonged decrease in performance. So, sudden occurrence of premature beats is often accompanied by reduced sports performance; after ruling out any underlying cardiopathy, training and/or dietary disequilibrium should be investigated. In our experiment, modifying training did not always cancel premature beats. In fact, only a long-term cohort study over several years, as was done with sedentary subjects (17), might provide a better assessment of the long-term prognosis of this type of premature beats.

In another 4 subjects, a notion of severe diet associated with intensive training was discovered. These were weight category athletes. The role of diet in this type of athlete has been reported (7, 33). Secret diuretic intake may also account for these effects. VPB, as was suggested by some authors (4, 7), indeed, hypokalaemia was evidenced in 11 cases, and its enhancing role in arrhythmia is well-known (1, 4). These last two hypotheses may explain why in our study 52% of recent VPB (n = 12) explored with LTE involved static athletes, as compared with 6 specialists from Group 1 and 5 from Group 3. A short episode of ventricular tachycardia (VT) was observed in a canoe specialist. Similar cases have been reported in sedentary subjects (2, 3, 35) or athletes (28, 31) who were apparently free of any cardiopathy. This was neither favoured by a R/T phenomenon (5), nor by an extended QT (28). Echocardiography was normal, and even if the classic benignity criteria (2, 36) were always present, this athlete presented with persistent extrasystole and prolonged decrease in performance. So, sudden occurrence of premature beats is often accompanied by reduced sports performance; after ruling out any underlying cardiopathy, training and/or dietary disequilibrium should be investigated. In our experiment, modifying training did not always cancel premature beats. In fact, only a long-term cohort study over several years, as was done with sedentary subjects (17), might provide a better assessment of the long-term prognosis of this type of premature beats.

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Lastly, exploring abnormal symptoms in athletes with LTE enabled us to evidence rhythmic disorders in 5 cases (25%), and this figure matches that reported for sedentary subjects (37). Despite such a low sensitivity, this examination appears to be justified to explore unexplained clinical signs in top-trained athletes.

Fig. 2 AVB frequency (%) in one runner over two years of training; R = Rest period; S = Specific training; C = Competition period; I = Intensive training; H = Holter monitoring.
References


