Long-term endurance sport practice increases the incidence of lone atrial fibrillation in men: a follow-up study

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Aims The aim of this study is to determine the incidence of lone atrial fibrillation (LAF) in males according to sport practice and to identify possible clinical markers related to LAF among marathon runners.

Methods and results A retrospective cohort study was designed. A group of marathon runners (n = 252) and a population-based sample of sedentary men (n = 305) recruited in 1990–92 and 1994–96, respectively, were contacted in 2002–03 and invited to attend an outpatient clinic to identify suggestive symptoms of having experienced an arrhythmia requiring medical attention. In those with suggestive symptoms of atrial fibrillation, medical records were reviewed. Finally, LAF was diagnosed on the basis of the presence of atrial fibrillation in an electrocardiographic recording. In the group of marathon runners, an echocardiogram was performed at inclusion and at the end of the study. The annual incidence rate of LAF among marathon runners and sedentary men was 0.43/100 and 0.11/100, respectively. Endurance sport practice was associated with a higher risk of incident LAF in the multivariate age- and blood pressure-adjusted Cox regression models (hazard ratio = 8.80; 95% confidence interval: 1.26–61.29). In the group of marathon runners, left atrial inferosuperior diameter and left atrial volume were both associated with a higher risk of incident LAF.

Conclusion Long-term endurance sport practice is associated with a higher risk of symptomatic LAF in men. This risk is associated with a larger left atrial inferosuperior diameter and volume in physically active subjects.

Introduction

Lone atrial fibrillation (LAF) is characterized by the presence of atrial fibrillation in the absence of structural heart disease or other identifiable causes of arrhythmia such as hypertension, hyperthyroidism, or alcohol use. Although uncommon causes for this arrhythmia have been described in recent years,1–3 the aetiology of an individual’s condition often remains unknown.4

Some studies have documented that long-lasting endurance sport practice is associated with an increase in the risk of LAF.5–9 These studies have shown that subjects who practise endurance sports are at approximately five times higher risk of LAF than those who are sedentary.6,8 Although atrial fibrillation is a common condition in athletes studied for arrhythmias,10 data on the incidence of LAF among sport practitioners are scanty.5,11

In contrast, some clinical markers such as hypertension or atrial enlargement are associated with a higher atrial fibrillation risk.12–14 However, few data exist to associate these clinical markers with LAF risk in endurance sport practitioners.11

The aim of this study is to determine the incidence of LAF in males according to sport practice levels and to identify possible clinical markers that increase the risk of LAF in a population of marathon runners.

Keywords
Atrial fibrillation;
Exercise;
Incidence
Methods

Design

A retrospective cohort study was designed with a group of marathon runners and a population sample of sedentary men. The two groups were followed-up to identify new episodes of symptomatic LAF. A scheme of the design of the study is shown in Figure 1. The study was approved by the local research Ethics Committee, it complies with the Declaration of Helsinki, and all the participants were informed about the aim of the study and signed an informed consent.

Subjects

The selection of 20–60-year-old male marathon runners was based in a previous study in which marathon runners were recruited in 1990–92. In that study, all the marathon runners living in Barcelona and participating in the Barcelona marathon of 1990 were invited to participate in order to evaluate the relationship between amount and intensity of leisure time physical activity and serum lipids. Finally, 252 of them participated in that study.

The group of sedentary men was taken from a representative sample of men aged 25–74 years who participated in a population-based cross-sectional study conducted in 1994–96 (n = 802) in a region close to Barcelona. All the participants who spent <300 kcal/day in leisure time physical activity were selected for this study (n = 305).

Basal examination

We used the Minnesota leisure time physical activity questionnaire to assess the physical activity practice during the year previous to inclusion in the study. This questionnaire had been previously validated for use among Spanish men. A score reflecting total energy expenditure in leisure time physical activity (total EEPA) was obtained.

An electrocardiogram was obtained in all individuals. Systolic and diastolic blood pressure values were measured following standardized methods. The use of medications to control blood pressure was recorded. Height and weight were measured with the individual in underwear and bare feet. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in metres. Subjects were classified as current cigarette smokers if they reported having smoked cigarettes during the previous year. A standardized questionnaire to record alcohol consumption was also administered and quantified as grams of consumption per day.

The marathon runners underwent a more extensive baseline cardiovascular evaluation that included an echocardiogram and an exercise test, performed according to the Bruce protocol. The exercise test was maximal and indications for stopping were those recommended by the American College of Sports Medicine. Time to exhaustion and presence of hypertensive response to exercise (maximal systolic blood pressure ≥210 mmHg) were recorded and are used for this analysis.

Two-dimensional echocardiogram was obtained with Acuson 128xp, with a computerized measurement and analysis module. Measurements were taken from the M-mode recording, following the American Society for Echocardiography recommendations. Five measurements of each assessed parameter were obtained, the highest and lowest values removed, and the mean of the three remaining values retained for analysis. In order to obtain more accurate information about the left atrial size, three diameters were obtained: the transverse antero-posterior diameter from the M-mode parasternal long-axis during systole (D1), and two orthogonal diameters from a four-chamber view (mediolateral, D2, and inferosuperior, D3). Left atrial volume was estimated by a prolate ellipse method using the following formula:

\[
\text{Left atrial volume} = \left(\frac{D1 \times D2 \times D3}{4.0\%}\right)
\]

Diastolic dysfunction was defined as an E/A ratio less than 1. All echocardiographic measurements were read by the same observer (L.Mol.), who had a coefficient of variability of <4.0%.

Follow-up examination and lone atrial fibrillation diagnosis

All participants were contacted and invited to attend an outpatient clinic where a standardized questionnaire, physical examination, and electrocardiogram were administered. The questionnaire was designed to identify symptoms suggestive of having experienced an arrhythmia requiring medical attention (hospital or emergency room admission, private clinic, etc). In those with symptoms suggestive of atrial fibrillation (palpitations, dizziness, chest pain, dyspnoea, etc.), medical records were reviewed. Finally, LAF was diagnosed on the basis of the presence of atrial fibrillation in an electrocardiographic recording in the absence of structural heart disease or other identifiable cause of arrhythmia, i.e. hyperthyroidism or alcohol abuse. The date of the event was defined as the diagnostic electrocardiographic recording of the first episode.

In the group of marathon runners, a second two-dimensional echocardiogram was obtained at the end of the follow-up using Acuson Sequoia with a computerized measurement and analysis module. The technical procedures and variables measured at inclusion were repeated. Moreover, in this group, a questionnaire to assess lifetime total physical activity practice was administered, so that researchers could estimate the number of lifetime hours of sport practice for each marathon runner.

Recruitment

Marathon runners 1990–92 n=252
- Physical exam EKG
- Retrospective medical record review
- Exercise test
- First echocardiogram

General population (sedentary) 1994–96 n=305
- Physical exam EKG
- Minnesota Leisure Time Physical Activity Questionnaire (MLTPAQ)
- Retrospective medical record review

End of follow-up

Clinical questionnaire
- Physical exam EKG
- Lifetime PA questionnaire
- Second echocardiogram

Figure 1 Scheme of the design of the study. EKG, electrocardiogram; MLTPAQ, Minnesota Leisure Time Physical Activity Questionnaire; PA, physical activity.
Statistical analysis

χ² test was used to compare proportions and Student’s t-test or Mann-Whitney test was used to compare means of continuous variables between groups. The Spearman correlation was used to determine the association between continuous variables.

The Kaplan–Meier survival curves were fitted for both groups according to sport practice. We used a left-truncated Cox regression model, with the date of inclusion in the study considered as the start of the follow-up. Multivariate proportional-hazard Cox models were fitted, adjusting for age and systolic and diastolic blood pressure to determine the association of sport practice and to establish clinical parameters for LAF events. A two-tailed nominal P-value less than 0.05 was considered statistically significant.

Results

Of the initial 252 marathon runners, one was excluded from the analysis because he underwent a prosthetic valve replacement, developing an atrial fibrillation during the follow-up; 183 completed the follow-up (72.9%), with a mean follow-up duration of 11.6 years. In the sedentary group, 290 of the eligible 305 participants were contacted during the follow-up (95.7%), with a mean follow-up duration of 6.4 years.

The characteristics of the sedentary participants and the marathon runners at baseline are presented in Table 1. Marathon runners were younger and showed lower BMI, heart rate, systolic and diastolic blood pressure and higher alcohol consumption, smoking prevalence, and leisure time physical activity practice than the sedentary participants. Two of the sedentary men (0.69%) and nine of the marathon runners (4.92%) presented with LAF during the follow-up. The 11 cases included in this study were paroxysmal or persistent LAF. No evidence of any atrial flutter episode during the follow-up was recorded. Of the nine marathon runners with LAF, six have continued in their usual training program, two had abandoned their training because of symptoms, and one had abandoned his training program before the first LAF episode.

The only statistically significant difference between participants with and without LAF was that those with LAF were thinner and practised more physical activity than those without LAF.

When we analysed marathon runners alone (Tables 2 and 3), the only statistically significant difference between groups according to the presence of LAF was left atrial size measured in the follow-up echocardiogram. Left atrial inferosuperior diameter was larger in the group with LAF (Table 3). Moreover, this diameter was the only one that increased from the first visit to the second visit in those marathon runners with LAF (P = 0.010). Left ventricular mass was similar in those with and without LAF, 200 (standard deviation: 35) and 201 (38) g, respectively, and left ventricular wall thickness was also similar, 10.0 (1.2) and 10.2 (1.3) mm, respectively. A higher proportion of hypertensive response to exercise was observed in the group of runners with LAF, although this difference was not statistically significant (Table 3).

A marginal difference (not statistically significant) for LAF incidence was found between the Kaplan–Meier survival curves corresponding to the sedentary and the marathon runner groups (Figure 2). However, endurance sport practice was associated with a higher risk of incident LAF in the multivariate age- and blood pressure-adjusted Cox regression models (Table 4, whole sample). When including all the participants lost in the follow-up as negative for LAF, the association between endurance sport practice and

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Characteristics of sedentary men and marathon runners presented as mean (standard deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sedentary (n = 290)</td>
</tr>
<tr>
<td>Age</td>
<td>50 (13)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>77.8 (11.0)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>170.4 (7.8)</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>26.7 (3.5)</td>
</tr>
<tr>
<td>Heart rate (bpm)</td>
<td>69 (11)</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>133 (19)</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>80 (11)</td>
</tr>
<tr>
<td>Smoking (%)</td>
<td>32.8</td>
</tr>
<tr>
<td>Alcohol (g/day)a</td>
<td>10 (10)</td>
</tr>
<tr>
<td>Baseline total EEPA (kcal/day)a</td>
<td>145 (76)</td>
</tr>
<tr>
<td>LAF (n)</td>
<td>2</td>
</tr>
<tr>
<td>Annual LAF incidence (/100 persons)</td>
<td>0.11</td>
</tr>
</tbody>
</table>

EEPA, energy expenditure in physical activity; LAF, lone atrial fibrillation.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Demographic and clinical characteristics of the marathon runners according to the presence of lone atrial fibrillation (LAF) presented as mean (standard deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LAF absence (n = 174)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>39 (9)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>69.0 (6.9)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>172.9 (6.5)</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>23.1 (1.9)</td>
</tr>
<tr>
<td>Heart rate (bpm)</td>
<td>64 (11)</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>125 (15)</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>76 (9)</td>
</tr>
</tbody>
</table>

EEPA, energy expenditure in physical activity.

aP-value obtained from the Mann–Whitney U-test.
LAF remained statistically significant (hazard ratio = 7.38; 95% confidence interval: 1.10–49.63; \( P = 0.040 \)).

In the group of marathon runners, left atrial inferosuperior diameter (Table 4, marathon runners) and left atrial volume measured in the follow-up (Table 4, marathon runners) were both associated with a higher risk of incident LAF, even after adjusting for age and systolic blood pressure. These results remained statistically significant when these left atrial measurements were indexed by body surface: OR = 1.36 (95% confidence interval: 1.10–1.68) for indexed left atrial inferosuperior diameter and OR = 1.12 (95% confidence interval: 1.02–1.23) for indexed left atrial volume. We further analysed the association of lifetime hours of sport practice with LAF risk in marathon runners. Neither considering this variable as continuous nor defining three groups according to tertiles resulted in an association of lifetime sport practice with LAF risk (data not shown).

**Table 3** Exercise test and echocardiographic characteristics of the marathon runners according to the presence of lone atrial fibrillation (LAF) presented as mean (standard deviation)

<table>
<thead>
<tr>
<th>Exercise test</th>
<th>LAF absence (n = 174)</th>
<th>LAF presence (n = 9)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to exhaustion (min)</td>
<td>16.6 (9.1)</td>
<td>15 (1.7)</td>
<td>0.707</td>
</tr>
<tr>
<td>Hypertensive response (%)</td>
<td>8.0</td>
<td>22.2</td>
<td>0.180</td>
</tr>
<tr>
<td>Initial echocardiogram</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right ventricle (mm)</td>
<td>20 (4)</td>
<td>21 (7)</td>
<td>0.374</td>
</tr>
<tr>
<td>LVId (mm)</td>
<td>32 (5)</td>
<td>30 (2)</td>
<td>0.125</td>
</tr>
<tr>
<td>LVIdd (mm)</td>
<td>53 (4)</td>
<td>52 (4)</td>
<td>0.346</td>
</tr>
<tr>
<td>Ejection fraction (%)</td>
<td>71 (7)</td>
<td>74 (4)</td>
<td>0.217</td>
</tr>
<tr>
<td>Left atrial anteroposterior diameter (mm)</td>
<td>48 (6)</td>
<td>49 (6)</td>
<td>0.664</td>
</tr>
<tr>
<td>Left atrial inferosuperior diameter (mm)</td>
<td>35 (4)</td>
<td>37 (3)</td>
<td>0.311</td>
</tr>
<tr>
<td>Left atrial mediolateral diameter (mm)</td>
<td>31 (9)</td>
<td>34 (7)</td>
<td>0.373</td>
</tr>
<tr>
<td>Left atrial volume (mL)</td>
<td>10.8</td>
<td>12.5</td>
<td>1.000</td>
</tr>
<tr>
<td>Left atrial enlargement (A-P diameter ≥ 40 mm) (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 4** Hazard ratio and 95% confidence interval of lone atrial fibrillation for sport practice and for left atrial inferosuperior diameter and volume adjusted for age and systolic blood pressure

<table>
<thead>
<tr>
<th>Hazard ratio</th>
<th>95% confidence interval</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole sample</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sport practice</td>
<td>8.80</td>
<td>1.26, 61.29</td>
</tr>
<tr>
<td>Marathon runners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Follow-up left atrial inferosuperior diameter (1 mm)</td>
<td>1.27</td>
<td>1.09, 1.48</td>
</tr>
<tr>
<td>Marathon runners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Follow-up left atrial volume (1 mL)</td>
<td>1.07</td>
<td>1.01, 1.14</td>
</tr>
</tbody>
</table>

**Discussion**

In this cohort study, we have observed LAF incidence to be higher in marathon runners than in the sedentary general population. Moreover, in the group of marathon runners, the only parameter associated with incident LAF was left atrial size, particularly left atrial inferosuperior diameter.

The results of our study confirm and add new information regarding the association of LAF with long-lasting endurance sport practice. This association has been observed in previous studies\(^5,7,8\) reporting that the frequency of LAF among sport practitioners was approximately three to five times higher than in the sedentary subjects. In the present study, the magnitude of the association between sport practice and LAF was higher, but the 95% confidence interval includes the previously reported estimations. Moreover, we have estimated the incidence of LAF among male sport practitioners and compared it with that of sedentary men. The
incidence observed in the group of marathon runners is similar to that reported in a previous small group of elite cross-country skiers. An important result of this study is that although sport practitioners show a higher relative risk of LAF when compared with sedentary people, the absolute risk of LAF in this active population remains low (<0.5/100 years).

Although LAF could be considered a benign condition, it is occasionally associated with severe and disturbing symptoms, causes a significant impairment of quality of life, and has been associated with increased mortality. However, the presence of these symptoms has not been analysed in this study, such as the presence of atrial ectopic beats or increased vagal tone. The observation that atrial size was a marker for LAF development suggests that, to some extent, atrial enlargement plays an important role in the development of this arrhythmia. However, we cannot rule out that frequent atrial ectopic beats or increased vagal tone may be necessary co-variables to trigger the arrhythmia.

The main limitation of this study is the limited number of events observed during the follow-up period. Nevertheless, the results are consistent with previous studies. Another limitation is that we include the reports of symptomatic atrial fibrillation as events. In some series, ~25% of the athletes with paroxysmal atrial fibrillation were asymptomatic; therefore, we probably are underestimating the real incidence of LAF in the populations under study. The duration of the follow-up period was longer in marathon runners than in sedentary men, although this difference is considered in the survival analysis. In contrast, we cannot disregard the possibility that those currently exercising had atrial fibrillation episodes usually symptomatic as opposed to those not exercising who could usually present asymptomatic atrial fibrillation episodes or seek medical evaluation of palpitations symptoms later than runners.

In conclusion, long-lasting endurance sport practice is associated with a higher risk of incident symptomatic LAF in men, but the absolute risk of this arrhythmia among sport practitioners remains low. This risk is associated with a larger left atrial inferosuperior diameter and volume in physically active subjects. Further studies are warranted to confirm and to elucidate the molecular and electrophysiological mechanisms underlying this association.

Conflict of interest: none declared.

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References
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