Is the risk of atrial fibrillation higher in athletes than in the general population? A systematic review and meta-analysis

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Aims
The aim of this study was to examine by a systematic literature review and meta-analysis whether the risk of atrial fibrillation (AF) is higher in athletes compared with not athletes.

Methods and results
A comprehensive systematic search was conducted for case–control studies that examined cases of AF or atrial flutter in athletes vs. controls. Extracted data from the eligible studies were meta-analysed using fixed effects model. Six case–control studies were eligible for meta-analysis. A total of 655 athletes and 895 controls were compared. Mean age was 51 ± 9 years and 93% were men. There were 147 (23%) vs. 116 (12.5%) cases of AF among athletes compared with controls. The overall risk of AF was significantly higher in athletes than in controls with odds ratio (95% confidence interval) = 5.29 (3.57–7.85), P = 0.0001, and Z-score = 8.08. For heterogeneity, the calculated x² = 2.92, P = 0.633, and I² = 0% were not significant.

Conclusion
The risk of AF is significantly higher in athletes compared with not athletes. However, this finding should be confirmed further in large-scale prospective longitudinal studies.

Keywords
Atrial fibrillation • Athlete

Introduction
The prevalence of atrial fibrillation (AF) in the general population increases gradually after 40 years of age but it increases sharply after 65 years of age. The prevalence of the disease in younger people is very low and almost absent before 25 years of age.1–3 Nevertheless, several observational studies have reported that the prevalence of AF increases in younger athletes after many years of training.4–7 This observation has been consequently confirmed in case–control studies comparing athletes with not athlete controls from the general population.8–13

Atrial fibrillation is presumably the most common tachyarrhythmia in athletes, but its aetiology and pathophysiology in this particular group of patients are still poorly understood.14 Athletes’ vulnerability to AF has been explained by the increased vagal tone with consequent bradycardia that may lead to dispersion of atrial repolarization, which in turn may increase the susceptibility to AF.15 Other studies have attributed the frequent occurrence of AF in athletes to remodelling process and atrial size enlargement.16 Recently, a published review by the expert authors in this field has highlighted this subject and suggested new larger longitudinal and mechanistic studies to clarify the association between AF and intense physical endurance.17

Atrial fibrillation may impair athletic performances and deteriorate athletes’ life quality. It is important to determine whether the risk of development of AF is higher in athletes compared with the general population. An overall quantification of the risk of AF in athletes across the available studies seems therefore necessary. The results may confer important clinical consequences because preventive measures—like reducing the intensity of endurance—may be considered to minimize the risk of AF crises.

Methods
Search strategy
We searched in the large electronic databases: Pubmed, EMBASE, and Cochrane, for all available studies reporting cases of AF in athletes...
compared with controls. The search was without language limitation and up to May 2009. The following keywords were used: atrial fibrillation, arrhythmia, athlete, sports, and exercise. References of the retrieved articles and the review articles published by expert authors on the subject were also screened for eligible studies.

**Study eligibility**

Case–control studies reporting the number of AF or atrial flutter in athletes compared with not athlete (control) groups were considered eligible for inclusion. We included atrial flutter events because these were included by the authors and because atrial flutter usually accompanies AF. Studies on athletic populations reporting arrhythmias/AF without controls or those that reported other types of arrhythmias but no AF or flutter were excluded.

**Data extraction**

Demographic data and the number of patients with AF in athletes and controls were extracted from each study. Two authors (J.A. and J.R.N.) performed searching, study evaluation, and data extraction independently, and any conflict was resolved by open consensus.

**Data synthesis**

The analysis included six studies. Two studies did not directly compare athletes with controls, accordingly the number of AF in each group was calculated from the provided data. The reported numbers of AF and flutter in athletes compared with the numbers of controls were pooled together, providing the overall odds ratio (OR) with 95% confidence interval (CI) for AF in the athlete population. We used weighted fixed effects model for data combination when the estimate of AF and flutter in athletes compared with not athlete (control) groups were considered significant. Meta-analysis package of the statistic software program STATA version 10 (STATA Corporation, Lakeway Drive, College Station, TX, USA) was used for all analyses.

**Results**

**Search results**

The results of the search are shown in the flow diagram (Figure 1). Finally, six case–control studies published in peer-review journals were eligible for the meta-analysis.

**Study and patient characteristics**

Study and patient characteristics are shown in Table 1. All the studies included athlete cases vs. approximately age-matched selected reference controls. Three of these studies were longitudinal prospective case–control studies with mean follow-up periods of 10, 6.4, and 28 years, respectively. The study by Mont et al. was also a prospective study on patients seen in the emergency room. One study was a retrospective data analysis of hospital records, and the last study was on patients who underwent ablation for atrial flutter and were followed up for 1 year.

A total of 655 athletes and 895 controls were included in the six studies. There were 147 (23%) vs. 116 (12.5%) cases of AF among athletes compared with their controls. Generally, the athletes were younger than their controls; however, in one study, the athletes were significantly younger than controls. The majority were men. The athletes practised different and mixed types of sports.

**Results of the analyses**

The results of the meta-analysis using fixed effects model are shown in Figure 2. The overall risk of AF was significantly higher in athletes than in controls: OR (95% CI) = 5.29 (3.57–7.85), \( P = 0.0001 \), and Z-score of 8.08. For heterogeneity, \( \chi^2 = 2.92, P = 0.633, \) and \( I^2 = 0\% \) were not significant, indicating fairly homogenous studies with no significant variation in between studies.

**Discussion**

The results of this meta-analysis, based on the currently available case–control studies, indicate that the risk of AF development in athletes might be significantly higher than in not athletes or the general population. The consistent finding of high OR in most of the studies, which were conducted in different countries and in various types of heavy endurance practicing athletes, seems convincing.

Mozaffarian et al. performed an interesting study on elderly persons to investigate the relationship between light–moderate physical activity and risk of AF. The included population was different from the relatively younger athletic populations in this meta-analysis. The results demonstrated that light–moderate physical activity was associated with decreased risk of AF, or stature was associated with increased AF risk. Recently, Aizer et al. have also investigated the relation of vigorous exercise to AF risk in a large cohort of healthy male physicians. The authors compared four exercising groups with increasing levels of endurance with a non-exercising group as reference. The multivariate analysis

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**Figure 1** Flow chart of the search process.

**Table 1** Study and patient characteristics are shown in Table 1. All the studies included athlete cases vs. approximately age-matched selected reference controls.
at 3-year follow-up showed that there was an increased risk of AF in the most exercising group, risk ratio 1.2 (1.02–1.41). At 12-year follow-up, where the individuals became older, this risk was no longer significant, but the risk remained higher in men 50 years of age and joggers in all analyses. The results of this study are thus in agreement with those of the current meta-analysis in athletes. Overall, it can be concluded that both vigorous exercise and stature most likely increase the AF risk, but this risk decreases with increasing age in exercisers, probably due to the beneficial effects of exercise on other AF risk factors.

A number of included studies in this meta-analysis also reported important echocardiographic measurements, particularly left atrial diameter or volume, but the reported data were heterogeneous and insufficient for combination.11,12 Athletes with lone AF had a larger left atrial volume than those without.11,12 Adjusted multivariate analyses showed that atrial volume was a strong predictor of AF. These findings supported the possibility of the correlation between atrial remodelling and risk of AF.

Two of the included studies8,13 in this meta-analysis had also followed up patients for all-cause mortality. Karjalainen et al.8 found a significantly lower mortality in athletes compared with controls. Simultaneously, they reported significantly lower cases of coronary artery disease in athletes. Baldesberger et al.13 found no significant difference in death between athletes and controls. The difference in the outcome between the two studies may be explained by the fact that Karjalainen et al. reported fewer risk factors like hypertension and diabetes in athletes compared with controls. Thus, despite the higher prevalence of AF which is a promoting cause of death, the results of these studies may indicate that lone AF in athletes is not necessarily associated with increased death or because other factors like the lower prevalence of coronary artery disease may reduce the overall death risk. Future large-scale longitudinal studies are therefore needed to follow up all-cause mortality, cardiac mortality, and hospitalization due to AF. Importantly, to understand the pathophysiology and mechanism of AF in athletes, comprehensive haemodynamic studies are needed. On the other hand, future randomized controlled studies might be considered to establish whether endurance limitation reduces disease severity or even cures it.

Table 1 Characteristics of the included studies

<table>
<thead>
<tr>
<th>Author/publication year</th>
<th>Type of athletes</th>
<th>Age (years) mean ± SD (athletes vs. controls)</th>
<th>Men (%)</th>
<th>Cases of AF/athletes</th>
<th>Cases of AF/controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karjalainen et al.8</td>
<td>Orienteers</td>
<td>48 ± 6 (46 ± 7 vs. 50 ± 5)</td>
<td>100</td>
<td>12/228 (5%)</td>
<td>2/212 (0.9%)</td>
</tr>
<tr>
<td>Heidbuchel et al.9</td>
<td>Mixed sports</td>
<td>55 ± 10 (53 ± 9 vs. 60 ± 10)</td>
<td>88</td>
<td>25/31 (81%)</td>
<td>50/106 (48%)</td>
</tr>
<tr>
<td>Elosua et al.10</td>
<td>Mixed sports</td>
<td>43 ± 12 (NA)</td>
<td>69</td>
<td>16/31 (51%)</td>
<td>35/129 (27%)</td>
</tr>
<tr>
<td>Molina et al.11</td>
<td>Marathon runners</td>
<td>45 ± 10 (39 ± 9 vs. 50 ± 13)</td>
<td>100</td>
<td>9/183 (5%)</td>
<td>2/290 (0.7%)</td>
</tr>
<tr>
<td>Mont et al.12</td>
<td>Mixed sports</td>
<td>48 ± 10 (NA)</td>
<td>100</td>
<td>83/120 (69%)</td>
<td>24/96 (25%)</td>
</tr>
<tr>
<td>Baldesberger et al.13</td>
<td>Cyclists</td>
<td>67 ± 7 (67 ± 7 vs. 67 ± 6)</td>
<td>100</td>
<td>6/62 (10%)</td>
<td>0/62 (0%)</td>
</tr>
<tr>
<td>Total studies (n = 6)</td>
<td>Mixed sports</td>
<td>51 ± 9</td>
<td>93</td>
<td>151/655 (23%)</td>
<td>113/895 (12.5%)</td>
</tr>
</tbody>
</table>

AF, atrial fibrillation, NA, not available, n, number.

Figure 2 Meta-analysis of AF risk in athletes compared with controls.
Although the results of the meta-analysis showed a clear and significant high risk of AF associated with athletic endurance, the results should be interpreted cautiously. The available sample of the studies was small and controls were not appropriately age-matched in all studies. The results may also be associated with some bias attributed to the variation in the level of endurance practised by the different types of athletes across the studies. Finally, it should be mentioned that most of these studies are performed in men, whereas the risk for women has not been well investigated.

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References