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Atrial Fibrillation in Physically Active Individuals: Effects of Pharmacological and Interventional Management on Athletic Quality of Life

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Abstract

Introduction: Atrial fibrillation (AF) is a common arrythmia in physically active individuals, particularly endurance athletes, raising important considerations regarding the cardiovascular effects of long-term high-intensity exercise. This review explores the correlation between AF and high-intensity training, focusing on how medical and interventional therapies impact athletic performance and quality of life.

Aim of the work: The aim of this work is to review the current literature regarding pharmacological and interventional management strategies for atrial fibrillation (AF) in athletes, with particular emphasis on their impact on exercise capacity and sport-specific quality of life. Furthermore, the review aims to highlight gaps in studies and propose directions for future research and therapeutic innovation in the management of AF among physically active individuals.

Material and Methods: The review was based on an analysis of articles published up to 2025 in the PubMed database, Google Scholar, and recent guidelines. The keywords we used included: atrial fibrillation, management, athlete, quality of life

Results: AF in athletes is often paroxysmal and asymptomatic, complicating diagnosis. Rate and rhythm control medications are frequently limited by negative effects on exercise capacity. Catheter ablation, especially pulmonary vein isolation, demonstrates superior rhythm control and allows athletes to return to peak performance. Anticoagulation, while necessary in some cases, presents bleeding risks in contact sports, requiring individualized approaches.

Conclusions: Management of AF in athletes must balance arrhythmia control with performance preservation. Catheter ablation offers the most consistent improvements in athletic quality

of life, whereas pharmacologic therapy is often restrictive. Tailored treatment strategies and further athlete-specific research are essential for optimizing care in this unique population.
Keywords: atrial fibrillation; management; athlete; quality of life

1. Introduction

Regular physical activity is an essential component of cardiovascular health, associated with reduced risk of hypertension, ischemic heart disease and stroke. In athletes, particularly those engaged in high-volume endurance training, long-term cardiovascular adaptation includes increased left ventricular mass, resting bradycardia, and enhanced stroke volume, commonly referred to as "athlete's heart" [1]. While moderate physical activity confers cardioprotective benefits, accumulating evidence suggests that chronic, high-volume endurance training may be associated with a paradoxical increase in arrhythmic risk, particularly atrial fibrillation (AF)[2,3].

AF is the most common arrhythmia in both the general and athletic populations[4,5]. Studies report AF prevalence in athletic populations ranging from 0.3% to over 12,8%, depending on sport type, training history, and age[6–10]. Clinically, AF in athletes is often paroxysmal and asymptomatic, complicating detection and delaying intervention. Importantly, management must not only focus on rhythm or rate control but also on preserving athletic performance and reducing psychological burden related to sport discontinuation[11].

The management of AF in physically active individuals is uniquely complex due to the need to balance effective symptom control with the preservation of exercise capacity and competitive performance. The selection of a treatment approach, whether based on pharmacological therapy, interventional procedures, or a combination of both, carries significant implications for the overall quality of life in physically active individuals. Beta-blockers and some calcium channel blockers are often poorly tolerated due to their negative chronotropic effects and impairment of peak performance metrics, such as VO_2 max and lactate threshold[12]. Antiarrhythmic drugs may reduce arrhythmia burden but carry proarrhythmic risk during exertion and may limit thermoregulation or endurance[1,5]. Catheter ablation, particularly pulmonary vein isolation (PVI), has emerged as the preferred rhythm control approach for symptomatic athletes, demonstrating superior maintenance of sinus rhythm, improvement in exercise performance, and reduced need for chronic pharmacotherapy. Surgical and hybrid approaches may be considered in selected cases, although data remain limited[13,14]. However, recovery timelines and recurrence risk must be considered when counseling athletes on return-to-play. Additionally, anticoagulation therapy remains an area of clinical complexity. While it is essential in reducing stroke risk in select athletes with elevated CHA_2DS_2-VA scores, it presents a significant challenge in contact sports due to elevated bleeding risk. The lack

of athlete-specific guidelines on anticoagulation underscores the need for individualized, risk–benefit assessments[15,16].

Taken together, these factors underscore the necessity of a management approach that is tailored to the specific physiological and psychological demands of athletes engaged in regular training and competition. In this context, the concept of athletic quality of life extends beyond the mere control of arrhythmia episodes. It includes the preservation of maximal physical performance capacity, the maintenance of psychological well-being, and the support of the individual and identity as a competitive athlete. A comprehensive understanding of how various medical and interventional therapies influence these interconnected domains is essential to ensure both effective arrhythmia management and the continuation of safe, high-level athletic participation.

2. Epidemiology and risk factors

Atrial fibrillation (AF) is significantly more prevalent in endurance athletes compared to the general population. The reported prevalence of atrial fibrillation among athletes varies widely, ranging from 0.3% to 12.8%, influenced primarily by factors such as the age of the athlete and the specific sport discipline involved[6–10]. Large-scale studies indicate that long-term endurance sports participation, particularly in men over 50 years of age, leads to a fivefold increased risk of AF[17]. This elevated incidence is explained by a correlation between physical activity and AF risk: while moderate exercise reduces the risk of arrhythmias, excessive and prolonged endurance training significantly increases it. Some studies confirmed that cumulative training hours exceeding 1500–2000 hours over a lifetime represent a critical threshold where AF risk begins to rise sharply, especially in competitive athletes[18]. Atrial fibrillation is strongly associated with age, and the incidence is generally increasing in older endurance athletes. However, some studies have demonstrated that, when comparing athletic and non-athletic populations, atrial fibrillation occurs more frequently in athletes aged 54 and younger. In contrast, among older individuals no such difference in AF incidence has been observed between athletes and non-athletes. These findings suggest that regular high-intensity physical activity may be associated with an earlier onset of atrial fibrillation, rather than an overall increased lifetime risk in older age groups[19]. Sex also plays a critical role. Male endurance athletes consistently show a higher risk of AF than females. This difference is attributed to sex-based variations in hormonal influences and differential autonomic responses to prolonged training[20]. The protective effect of estrogen in women is hypothesized to modulate atrial electrophysiology and fibrotic processes, delaying or reducing AF development[21]. The type

of endurance sport practiced further modifies AF risk. Sports involving prolonged dynamic effort and sustained volume load on the heart, such as marathon running, swimming, rowing, and cycling, are particularly associated with increased AF incidence[22–24]. Repetitive right and left atrial stretching in these sports contributes to structural atrial enlargement and fibrosis, creating a substrate conducive to arrhythmogenesis[25].

3. Pathophysiological Mechanisms

In endurance athletes, atrial fibrillation results from the combined effects of functional and structural cardiac adaptations. Cardiac output adaptation during exercise is mediated by gradual sympathetic stimulation accompanied by a parallel withdrawal of parasympathetic nervous system. Following exercise cessation, the persistence of heightened sympathetic effect in combination with abrupt parasympathetic reactivation creates a transient autonomic imbalance characterized by simultaneous activation of systems, which has been shown to promote a proarrhythmic conditions leading to atrial arrhythmias[26]. Structurally, long-term exposure to volume overload results in left atrial dilation and fibrotic remodeling, promoting reentrant circuits[27]. Additionally, repeated strenuous exertion triggers low-grade systemic inflammation and oxidative stress, with elevated levels of cytokines such as IL-6 and CRP. These inflammatory processes contribute to atrial structural remodeling and electric heterogeneity, which induces development of atrial fibrillation[28].

4. Clinical Presentation

Athletes with atrial fibrillation often present with short, paroxysmal episodes, typically vagally mediated and occurring during rest or after meals. Symptoms are frequently mild or even absent[23]. In contrast, sedentary individuals usually develop persistent or permanent atrial fibrillation, often with more pronounced symptoms such as dyspnea, palpitations, or fatigue. While the overall stroke risk remains a concern in both populations, data suggest that athletes may experience fewer thromboembolic complications despite higher AF incidence, possibly due to favorable vascular profiles[29].

5. Diagnosis

Diagnosing atrial fibrillation in endurance athletes is inherently challenging due to the arrhythmia's paroxysmal nature and frequent absence of symptoms. A 12-lead electrocardiogram (ECG) remains the diagnostic gold standard for atrial fibrillation (AF),

requiring at least 10 seconds of continuous rhythm documentation to confirm the diagnosis[30]. Nevertheless, arrhythmias in affected individuals may occur infrequently and only for a very short time, making detection challenging. As a result, extended-duration non-invasive ECG monitoring is commonly used both for arrhythmia screening and for evaluating unexplained cardiac symptoms[31]. Despite its diagnostic utility, the Holter ECG may be limited by user discomfort and frequent signal artifacts during physical exertion. Consequently, wearable heart rate monitors and pulse oximeters are often utilized in athletic settings. However, these technologies are not medically certified devices and, in comparison to Holter ECG, they have low specificity and sensitivity as primarily due to motion artifacts and insufficient arrhythmia discrimination[32]. Misinterpretation can lead to either overdiagnosis or missed AF episodes, underscoring the importance of clinician expertise in athlete-specific ECG patterns. The increasing use of wearable ECG technologies, such as smartwatch-based single-lead ECGs and photoplethysmography (PPG)-based devices, has opened new avenues for early detection. These tools have shown moderate-to-high accuracy in identifying AF and are particularly beneficial for athletes who experience infrequent or nocturnal symptoms[33]. Despite their growing adoption, limitations in data validation, false positives due to motion artifacts, and device compliance remain obstacles to widespread implementation in athletic populations[34]. Sinus bradycardia, first-degree AV block, and early repolarization changes are common in trained individuals and may mask or mimic arrhythmogenic processes. Serial ECG comparison and familiarity with athlete-specific ECG adaptations are essential to improve diagnostic accuracy[35]. Early detection of atrial fibrillation in athletes is essential to prevent thromboembolic events and progressive atrial remodeling, especially given the arrhythmia's often asymptomatic and paroxysmal nature in this population. Prompt diagnosis enables risk stratification and therapeutic intervention without compromising athletic performance[36].

6. Pharmacological Management of Atrial Fibrillation in Athletes

6.1. Rate Control Therapies

Rate control is a key strategy in managing atrial fibrillation (AF), particularly in cases of permanent AF or when rhythm control is not feasible. The 2024 ESC Guidelines for AF Management recommend beta-blockers as the primary agents for rate control, due to their effectiveness in reducing AV nodal conduction and ventricular rate. However, in athletes, the use of beta-blockers is limited by their negative chronotropic effects, which impair peak cardiac output and reduce exercise capacity[15]. The 2020 ESC Sports Cardiology Guidelines recognize

that beta-blockers significantly limit athletic performance, particularly in endurance sports where high heart rates are required for optimal performance. Therefore, non-dihydropyridine calcium channel blockers, such as verapamil and diltiazem, are often preferred in young athletes with preserved systolic function and no underlying structural heart disease. These agents effectively slow atrioventricular conduction and reduce myocardial contractility, providing adequate rate control with a less pronounced impact on VO_2 max and exercise performance compared to beta-blockers[1]. Nevertheless, fatigue and diminished training capacity have been reported in some individuals, particularly at higher dosages[12]. However, in highly trained individuals with resting bradycardia, both beta-blockers and calcium channel blockers must be used cautiously to avoid excessive bradycardia and impaired performance. Regular monitoring with resting ECG and exercise testing is recommended to adjust dosing and ensure tolerability[1].

6.2. Rhythm Control with Antiarrhythmic Drugs

In competitive athletes, especially those with paroxysmal AF or significant symptoms, rhythm control is often preferred to allow continued participation in high-intensity sports. There is recommend Class IC antiarrhythmic drugs such as flecainide or propafenone for patients without structural heart disease or significant left atrial enlargement. These agents are particularly suited for young, otherwise healthy athletes and have minimal negative effects on performance when used appropriately[1,15]. However, they carry a proarrhythmic risk, particularly during exertion or in the presence of latent structural abnormalities, which may limit their use in unscreened athletes. The use of Class III drugs, such as sotalol or amiodarone, is more restricted. Sotalol with both beta-blocking and Class III properties, may impair exercise capacity through reduction of heart rate and QT interval prolongation. The article notes potential arrhythmogenicity during physical exertion and recommends caution in athletes engaged in high-level training[12]. Amiodarone, while highly effective in maintaining sinus rhythm, is strongly discouraged for long-term use in athletes due to extracardiac toxicity, including pulmonary fibrosis, thyroid dysfunction, and hepatic injury. These effects lead to impaired thermoregulation and exercise tolerance which can negatively influence long-term athletic training and health, making it a less desirable option for highly active individuals. When antiarrhythmic drugs are not well tolerated or contraindicated, catheter ablation is increasingly considered an early strategy in athletes to reduce arrhythmic burden and minimize pharmacologic side effects. [1,15].

6.3. Anticoagulation: Considerations in Athletic Population

The decision to initiate oral anticoagulation (OAC) in athletes with AF follows the CHA_2DS_2-VA score, as in the general population. Most athletes, due to young age and low prevalence of comorbidities, score 0 or 1 and are not immediate candidates for anticoagulation. However, in those with a score ≥2, OAC is clearly recommended[15]. Direct oral anticoagulants (DOACs) such as rivaroxaban and apixaban are preferred over warfarin due to their lower risk of intracranial bleeding, stable pharmacokinetics, and absence of dietary restrictions[37]. Nonetheless, in contact sports where potential bleeding risk is high such as ice hockey, soccer, American football, basketball the bleeding risk from trauma must be weighed carefully against the stroke risk[38]. In these sport disciplines the use of intermittent anticoagulant therapy may be considered based on the competition schedule. The use of intermittent anticoagulant therapy is strategy in which oral anticoagulants are paused around the time of athletic activity, and it is primarily considered for athletes on long-term anticoagulation who face career-limiting restrictions due to bleeding risk during play. Such an approach may be applied after at least 3 months of uninterrupted full-dose anticoagulation, and it is important to identify a "safe" plasma drug concentration with a personalized pharmacokinetic/pharmacodynamic (PK/PD) study, below which the risk of traumatic bleeding is presumed to be acceptably low[39].

7. Interventional Therapies for Atrial Fibrillation

7.1. Catheter Ablation

Catheter ablation particularly pulmonary vein isolation (PVI) has emerged as the preferred rhythm control strategy in athletes with symptomatic atrial fibrillation (AF), particularly in cases where antiarrhythmic drug therapy proves ineffective or poorly tolerated. Evidence from interventional studies in athletic populations indicates that between 48% and 74.6% of patients maintain sinus rhythm without antiarrhythmic medication following a single ablation procedure, with overall success rates increasing to approximately 81% after repeat intervention[13,40]. These findings align with outcomes reported in broader interventional cohorts, indicating that catheter ablation in athletes achieves rhythm control rates that are comparable to, and in some cases exceed, those observed in the general population. This favorable response is likely attributable to the younger age profile, lower prevalence of structural heart disease, and superior baseline cardiovascular conditioning characteristic of athletic individuals[41]. The 2024 EHRA Expert Consensus Statement supports catheter ablation as a first-line option for rhythm

control in athletes with symptomatic paroxysmal AF and minimal structural heart disease. It emphasizes that the pulmonary veins are the principal arrhythmic source in this population, and non-pulmonary vein triggers are rarely encountered, making PVI alone sufficient in most cases[42].

7.2. Risks, Recovery, and return-to-play Timelines

The safety profile of catheter ablation in athletes is favorable, with complication rates similar to the general population. Transient pericarditis and vascular access issues are the most common events, but severe complications like cardiac tamponade or stroke are rare[40]. Regarding return-to-sport, most athletes can resume moderate training within 2–4 weeks and competitive sports within 6–12 weeks, assuming freedom from arrhythmia and absence of procedural complications. While no fixed duration is mandated, 2–3 months post-ablation is identified as a vulnerable period due to post-procedural atrial inflammation, which may transiently increase the risk of atrial fibrillation recurrence. During this time, careful monitoring is recommended before full clearance is granted for intensive or contact sports. The EHRA 2024 statement advises individualized clearance protocols involving ECG and exercise testing to confirm stability before full return to high-level sport[42].

7.3. Long-Term Efficacy and Recurrence Rates in Active Individuals

Long-term efficacy of catheter ablation in athletes with atrial fibrillation (AF) is influenced by the unique physiological adaptations associated with high-endurance training. In a prospective cohort study by Koopman, involving 94 endurance athletes undergoing pulmonary vein isolation (PVI), the single-procedure success rate (freedom from AF) at 3 years was 48%, increasing to 85% after multiple procedures. These outcomes were comparable to a matched non-athletic control group, indicating that, with appropriate case selection, PVI achieves durable rhythm control in athletic populations[41]. Liu further investigated ablation outcomes in endurance athletes and observed a higher recurrence rate over extended follow-up. At 24- and 36-months post-procedure, athletes demonstrated 35% and 42% lower rates of freedom from atrial arrhythmias compared to matched non-athletes, respectively. Despite these findings, 77% of athletes were able to return to their previous level of training and competition, emphasizing the functional benefit of ablation even in the presence of arrhythmia recurrence[43]. These findings underscore that while ablation provides substantial symptomatic relief and supports return-to-sport goals, endurance athletes may remain

at elevated risk of recurrence due to persistent triggers related to atrial remodeling and autonomic imbalance. As highlighted in the 2024 EHRA Expert Consensus, athletes should be closely monitored post-ablation and counseled on potential need for repeat procedures to maintain long-term rhythm control[42].

7.4. Comparison with Pharmacological Treatment

In direct comparisons, catheter ablation offers significantly better rhythm control and quality-of-life scores compared to medical therapy. Pharmacological options, including beta-blockers and Class IC/III antiarrhythmic agents, are often associated with reduced exercise capacity, fatigue, and impaired chronotropic response which are performance-limiting for athletes[41]. The EHRA 2024 consensus recommends ablation over medical therapy for active individuals with high symptom burden or intolerance to antiarrhythmic medications. In such cases, early ablation can restore full athletic capacity and minimize exposure to drug side effects, supporting its role as first-line therapy in competitive athletes[42].

7.5. Surgical Options and Hybrid Approaches

Surgical ablation procedures, including the Cox-Maze IV and thoracoscopic epicardial ablation, may be considered in patients with persistent or long-standing persistent AF, especially after failed catheter ablation. These techniques provide high success rates in maintaining long-term sinus rhythm, particularly when atrial enlargement or fibrosis is present[44]. Hybrid ablation approaches which combine thoracoscopic epicardial ablation with endocardial catheter-based mapping, may offer improved efficacy in complex cases. These approaches may be advantageous in athletes with atrial remodeling due to endurance training and may reduce arrhythmia recurrence when pulmonary vein isolation alone proves insufficient, although data including this population is limited[45].

8. Impact of Treatment on Quality of life of the Athletes

Management of atrial fibrillation (AF) in athletes not only aims to restore sinus rhythm but also to preserve or enhance athletic quality of life, a multidimensional concept encompassing physical performance, psychological resilience, and return-to-play capability. While “athletic quality of life” lacks a universal definition, it is often inferred through metrics such as return to competition, exercise performance testing such as VO_2 max and self-reported outcomes related to training tolerance and symptom burden[12]. Post-treatment performance outcomes vary

based on the intervention type and individual athlete profiles. Catheter ablation has been shown to significantly improve exercise tolerance and reduce arrhythmic burden in endurance athletes. For example, objective improvements in maximal oxygen uptake (VO_2 max) and workload tolerance were demonstrated after ablation, supporting both physiological and psychological recovery[14]. Similar improvements have been corroborated in other ablation cohorts of athletes, with many resuming full training and competition levels within months[43]. Nevertheless, athletes may experience anxiety related to recurrence or fear of being medically disqualified, especially if symptoms persist or re-emerge during high-intensity efforts. Psychological stress related to uncertainty about future performance or career longevity is commonly reported in this population[5]. These concerns necessitate not only tailored follow-up and shared decision-making but also reassurance from sports cardiology teams that understand the competitive mindset. Patient-reported outcomes indicate that a substantial proportion of athletes perceive catheter ablation as life-restoring, citing improvements not only in symptom control but also in confidence to resume training without fear of adverse events[3].

9. Future Perspectives and Research Needs

Future perspectives in the management of atrial fibrillation (AF) among athletes should be increasingly focus on the development of individualized treatment strategies adjusted specifically to the needs of competitive athletes. Advances in ablation technology, including pulsed field ablation and ultra-low temperature cryoablation, offer the promise of safer and more tissue-selective interventions with lower recurrence rates, which could better align with the demands of competitive sport. However, these techniques remain in the early stages of clinical adoption and require further validation through prospective trials[46,47]. Importantly, their efficacy, safety, and impact on performance must be systematically evaluated in athletic populations, underscoring the need for targeted research within this subgroup. Simultaneously, early-stage exploration of gene-based therapies may eventually offer novel options for rhythm stabilization in genetically predisposed athletes, although these approaches remain experimental. Despite ongoing innovations, current evidence is limited by the absence of large-scale longitudinal studies focused specifically on athletic populations. Many existing trials exclude elite athletes or fail to stratify outcomes by sport discipline or training intensity, leading to significant gaps in clinical knowledge. Additionally, there is a clear need for quality-of-life assessment tools and validated clinical outcome measures tailored to athletes, encompassing both physical performance and psychological aspects such as anxiety about recurrence, fear

of disqualification, and training restrictions. Particular consideration should also be given to the use of anticoagulant therapy, which presents specific challenges for athletes involved in contact sports due to heightened bleeding risk. Although current guidelines recommend individualized evaluation of risk and benefit, more prospective data are required to guide safe return to play decisions in anticoagulated athletes. Finally, further research addressing sex related differences is essential, as most available data are derived from male cohorts, despite the possibility that physiological differences may affect treatment response, recurrence risk, and drug tolerance in female athletes. Targeted investigations in these areas are necessary to optimize the management of atrial fibrillation in this distinct population.

10. Conclusions

The management of atrial fibrillation (AF) in physically active individuals demands a balance between effective symptom control and the preservation of athletic capacity. Pharmacological therapy, including rate and rhythm control agents, remains the first-line approach in many cases, particularly in athletes with paroxysmal or infrequent AF episodes. While non-dihydropyridine calcium channel blockers and Class IC antiarrhythmic drugs can achieve adequate rhythm control, they frequently exert negative effects on exercise performance, including diminished VO_2 max, reduced cardiac output during exertion, and exercise intolerance. Such effects may be particularly limiting for elite athletes and those engaged in endurance sports, where cardiovascular output is critical to performance and competitive viability. Catheter ablation, especially pulmonary vein isolation, has emerged as a more definitive treatment for symptomatic athletes, offering high rates of sinus rhythm maintenance and facilitating return to full physical activity. Most studies reviewed report substantial improvements in exercise tolerance, reduction in symptom burden, and enhanced quality of life following successful ablation. Importantly, these benefits occur without the limitations on performance commonly associated with pharmacologic therapy, which makes ablation a particularly appealing option for competitive athletes. Anticoagulation remains a complex component of AF management in athletic populations. While it is essential for stroke prevention in high-risk individuals, its use is challenging in athletes engaged in contact or high-fall-risk sports due to the potential for trauma-induced bleeding. Intermittent anticoagulation strategies may be considered in select cases, but long-term management must be individualized and guided by careful risk–benefit assessment and ongoing monitoring. Surgical and hybrid ablation approaches, though less commonly employed, may offer therapeutic alternatives in cases of failed catheter ablation

or advanced atrial remodeling. These interventions can restore rhythm in highly symptomatic or refractory athletes but require longer recovery periods and carry procedural risks that must be weighed against potential gains in arrhythmia control. In summary, the selection of therapy must be individualized, considering efficacy, safety, and the potential impact on athletic performance. Both pharmacological and interventional approaches play important roles in the management of atrial fibrillation in physically active individuals. Among these, catheter ablation offers the most consistent benefits in terms of rhythm control and quality of life. Anticoagulation and surgical interventions require careful consideration of sport-specific risks and patient characteristics. Continued research is essential to fill existing gaps in long-term outcomes and to develop care strategies tailored specifically to athletic populations.

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