



Exercise in individuals with atrial fibrillation

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Abstract

Background Despite the high prevalence of atrial fibrillation (AF), there is a lack of recommendations for physical activity and exercise in individuals with AF, including athletes with AF.

Methods With the aim to review studies that have investigated effects and safety of exercise in individuals with AF, we conducted a literature search in Pubmed using the key words *atrial fibrillation AND exercise OR physical activity OR exercise/adverse effects OR adverse outcome*.

Results Observational data from one registry suggest that regular exercise is associated with reduced mortality in AF patients. Three randomized controlled trials (RCTs) have demonstrated that 12-week exercise interventions might reduce the burden of AF and improve exercise capacity by 10–16% in patients with paroxysmal or persistent AF. Three small RCTs suggest that exercise might improve exercise capacity with 15–41% in patients with permanent AF. Exercise might improve quality of life in patients with AF. Data on safety of exercise are sparse. No studies have evaluated the effect of exercise in athletes with AF.

Conclusions Despite weak evidence, we suggest that individuals with AF should exercise regularly after evaluation of underlying conditions. Recommendations should be individualized. There is a lack of data to support exercise recommendations in athletes with AF.

Keywords Atrial fibrillation · Arrhythmia · Exercise · Physical activity · Athletes

Introduction

Atrial fibrillation (AF) is associated with reduced quality of life (QoL), a high symptom burden, and increased risk of stroke, other cardiovascular morbidities and death [1]. The number of individuals affected by AF worldwide has been estimated to be > 33 Million [2]. The prevalence of AF is strongly related to age [3], and the aging population is an important factor for the increase in AF prevalence over time [4].

Regular physical activity reduces the risk of AF compared to physical inactivity [5], and moderate regular physical activity is recommended to prevent AF [1, 6]. Exercise is well documented and recommended both in primary and secondary cardiovascular prevention and in cardiac rehabilitation (CR) [7–9], but to our knowledge, guidelines for physical activity and exercise do not exist for AF patients. At the same time, studies have revealed a surprisingly high prevalence of AF of among endurance athletes [10–13]. Despite increased awareness of this group of AF patients [14, 15], few authors have addressed exercise recommendations for athletes with AF [16].

AF is classified into first diagnosed, paroxysmal, persistent or permanent AF [1]. Furthermore, clinical subtypes of AF have been suggested, including AF secondary to underlying structural heart diseases and AF in athletes [1]. Athletes with AF are often young or middle-aged and usually do not have underlying heart diseases or traditional risk factors for AF [14]. Other AF subtypes often present with cardiovascular risk factors such as hypertension, obesity and diabetes that are all independently associated with AF.

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In this paper, we review the current research on physical activity and exercise in individuals with AF. The paper adds to previous reviews by discussing exercise recommendations in different subtypes of AF, including athletes.

Effects of exercise in atrial fibrillation subtypes

With the aim to review studies that have investigated effects and safety of exercise in individuals with AF, we performed a Pubmed search with the keywords *atrial fibrillation AND exercise OR physical activity OR exercise/adverse effects OR adverse outcome* (see supplementary material for the full search strategy). Reference lists of selected articles were manually searched to ensure that all relevant papers had been identified. Review papers and meta-analyses were excluded. Out of 796 published papers, 11 were identified as relevant. In addition, three studies identified by two other reviews and one study previously known to the authors were included (Fig. 1, supplementary material). Relevant studies identified in this review are shown in Table 1.

Paroxysmal and persistent atrial fibrillation

Three randomized controlled trials (RCTs) have investigated effects of exercise in patients with paroxysmal or persistent AF. In a study by Malmo et al., patients were randomized to aerobic interval training ($n=26$) for 12 weeks or to a control group ($n=25$) continuing their regular exercise habits [17]. The intervention consisted of three weekly bouts of four 4-min intervals at 85–95% of peak heart rate (HR) performed as walking or running on a treadmill. Aerobic interval training reduced the arrhythmic burden and was associated with significant improvements in AF symptoms, left atrial and left ventricular (LV) function, lipid levels, and QoL. Exercise capacity was improved by an average of 10%. There was one event of VT during exercise testing in the control group (previously undiagnosed ischemic heart disease). In a study by Skielboe et al., patients with paroxysmal AF were randomized to exercise at either low ($n=38$) or high ($n=38$) intensity (50 and 80% of maximal perceived exertion) for 12 weeks [18]. The interventions consisted of 60-min bouts of supervised exercise with interval training on ergometer bike and varying circuit exercise on the floor. Burden of AF did not differ between the groups. Exercise capacity was improved with both low and high exercise intensity, by 16 and 14%, respectively, with no statistical difference between the groups. No serious adverse events related to exercise were observed during the study period. In a study by Risom et al., AF patients treated with ablation were randomized to exercise-based CR for 12 weeks ($n=105$) or a control group who received usual care ($n=105$) [19]. The CR included three weekly bouts of strength and endurance exercise, and was associated with improved exercise capacity compared

to usual care. Two serious adverse events (AF in relation to exercise and death unrelated to rehabilitation) were observed in the exercise group, one in the usual care group (death unrelated to intervention).

Permanent atrial fibrillation

Two RCTs have assessed exercise in patients with permanent AF. In a study by Hegbom et al., 13 patients were randomized to three weekly 45-min bouts of exercise for 8 weeks [23]. The exercise bouts consisted of aerobics at 70–90% of peak HR and strengthening exercise. Compared to a control group ($n=15$) without exercise, HR variability, exercise capacity and QoL improved, and HR at rest and during exercise decreased during the intervention. Adverse events were not reported in this study. In a study by Osbak et al., 47 patients with permanent AF were randomized to 12 weeks with three weekly 60-min bouts of exercise at $\leq 70\%$ of estimated maximal exercise capacity ($n=24$) or to a control group without exercise intervention ($n=23$) [25]. The intervention included ergometer cycling, walking on stairs, running, fitness training and interval training, and was associated with improved muscle strength, exercise capacity and QoL. No adverse events were observed.

Atrial fibrillation with underlying heart disease

In a multicenter RCT (The HF-ACTION Study) of participants with heart failure, 193 individuals with AF received supervised training (walking, treadmill or cycle ergometer) three times weekly for 36 sessions, followed by transition to a home-based exercise program for 2 years [28]. After a median follow-up of 2.6 years, there were no differences in mortality, hospitalization rates, AF events or other endpoints between the exercise and the control group ($n=189$).

In the RACE 3 trial, 119 patients with persistent AF and heart failure were randomized to multi-component CR including moderate physical activity. After 12-month follow-up, sinus rhythm was present in 75% patients in the intervention group versus 63% in the control group ($n=126$, no information about physical activity in the control group) [29].

Atrial fibrillation in athletes

Very few studies have addressed AF in athletes. In a 9-year follow-up study of 30 male athletes with paroxysmal AF and a mean age of 47.1 years, 50% still had symptomatic paroxysmal AF 9 years later, while 23% had no symptoms of AF and 17% had developed permanent AF [30]. At baseline and follow-up, respectively, 23 and 7% had symptomatic attacks during exercise, and 60 and 41% had symptoms requiring termination of all sport

Table 1 Studies on effects of exercise in subgroups of patients with atrial fibrillation

Author (year)	Patient population mean age ± SD	Study design and type of exercise	Main results
A. Paroxysmal or persistent atrial fibrillation			
Malmö et al. (2016) [17]	n = 26 (77% men) 56 ± 8 years Control group: n = 25 (88% men) 62 ± 9 years	RCT Aerobic interval training: 3 weekly 45-min bouts with 4 × 4 min intervals with high intensity (85–95% of max HR) for 12 weeks Control group: Regular exercise habits	Reduced time in AF (8.1–4.8%) after interval training, increased time in AF (10.4–14.6%) in control group (p = 0.001 between groups). Improved peak VO ₂ after interval training (3.2 ml O ₂ /kg/min versus –0.3 ml O ₂ /kg/min in control group)
Skjelboe et al. (2016) [18]	n = 37 (22 men) 61 ± 3 years Control group: n = 33 (19 men) 64 ± 3 years	RCT 2 weekly 60 min bouts with high intensity (80% of perceived max exertion measured with Borg scale) during 12 weeks Control group: 2 weekly 60-min bouts with low intensity (50% of perceived max exertion) during 12 weeks	No difference in burden of AF between low- and high-intensity exercises. Improved peak VO ₂ (3.62 ml O ₂ /kg/min with low intensity, 2.87 ml O ₂ /kg/min with high intensity), no statistical difference between groups
Risom et al. (2016) [19]	n = 105 (70% men) 60 ± 9 years Control group: n = 105 (73% men) 73 ± 12 years After ablation for AF	RCT 3 weekly bouts of strength exercise and endurance exercise for 12 weeks, initiated 1 week after ablation for AF Control group: Usual care	Improved peak VO ₂ after exercise compared to control group (24.3 ml O ₂ /kg/min versus 20.7 ml O ₂ /kg/min, p = 0.003, after 4 months)
B. Permanent atrial fibrillation			
Mertens et al. (1996) [20]	n = 20 (65% men) 61 years	Prospective cohort study 1-year follow up 5 weekly bouts of walking at moderate intensity (60–80% of max HR)	Improved peak VO ₂ (mean increase 14.8 to 17.0 ml O ₂ /kg/min) after 12 months
Vanhees et al. (2000) [21]	n = 19 (89% men) 63 ± 6 years Control group without AF: n = 44 (93% men) 63 ± 4 years n = 30	Prospective cohort study 3 weekly 90-min bouts during 12 weeks	Improved peak VO ₂ (1271 to 1496 ml O ₂ /min in patients with AF)
Hegbom et al. (2006) [22]		Pooled data from RCT (the control group received the exercise intervention after the study period of the RCT) 3 weekly 45-min bouts with moderate to high intensity (70–90% of max HR) during 8 weeks	Improved exercise capacity, heart rate variability and QoL. Decreased HRs at rest and during exercise
Hegbom et al. (2007) [23]	n = 13 (100% men) 62 ± 7 years Control group: n = 15 (87% men) 65 ± 7 years	RCT 3 weekly 45-min bouts with moderate to high intensity (70–90% of max HR) during 8 weeks Control group: No exercise	Improved exercise capacity (41% increase in cumulative work at Borgs scale), QoL, and ADL, reduced symptom frequency and severity after 2 months
Plisienne et al. (2008) [24]	n = 10 (7 men) 59 ± 10 years	Prospective cohort study 16-week follow-up 2 weekly 45-min bouts of walking/jogging	Improved exercise capacity (running speed at lactate threshold 113 versus 105 m/min)

Table 1 (continued)

Author (year)	Patient population Mean age ± SD	Study design and type of exercise	Main results
Osbak et al. (2012) [25]	n = 24 (75% men) 70 ± 7 years Control group: n = 23 (74% men) 71 ± 8 years	RCT 3 weekly 30–60-min bouts with moderate intensity (70% of max HR) during 12 weeks Control group: No exercise	Maximal exercise capacity increased from 160 to 174 W (decreased from 135 to 127 W in the control group, $p = 0.001$ between groups)
Author (year)	Patient population mean age ± SD (or range)	Study design and type of exercise	Main results
C. Atrial fibrillation with underlying heart disease and cardiovascular risk factors			
Pathak et al. (2015) [26]	n = 308 (150 men) 58 ± 12 years, body mass index ≥ 27 kg/m ²	Prospective cohort study 49 ± 19-month follow-up Tailored exercise recommendation, exercise intensity < 85% of max HR	Higher fitness gain (≥ 2 METs) associated with larger reduction in AF burden and symptom severity. Total arrhythmia-free survival rates were 17% in the low, 76% in the adequate, and 84% in the high cardiorespiratory fitness groups ($p < 0.001$)
Proietti et al. (2017) [27]	n = 2442 (60% men) 70 (62–77) years 26% paroxysmal AF	Prospective cohort study 1-year follow-up Physical activity (from none (< 3 h/week for < 2 years) to intense (7 h/week for ≥ 2 years)) was self-reported	Physical activity associated with lower risk of CV death, thromboembolic events and bleeding (occasional OR 0.48, regular OR 0.40 and intense activity OR 0.29 compared to inactivity), but not with arrhythmia progression
Luo et al. (2017) [28]	382 Patients with AF or history of AF, and HF (EF < 35%) and NYHA functional class II to IV (84% men) 63 (56–73) years n = 193 Control group: n = 189	Multicenter RCT 12 weeks with 3 weekly 90-min bouts of aerobic exercise, then 120 min weekly home-based exercise for 2 years Median follow-up 2.6 years	No differences in mortality, hospitalization rates, AF events, exercise capacity, 6-min walk test or health status
Rienstra et al. (2018) [29]	n = 119 patients with early persistent AF and mild–moderate HF Control group: n = 126, conventional therapy	RCT Multi-component cardiac rehabilitation including moderate physical activity	Improved maintenance of sinus rhythm (75% compared to 63% in the control group, $p = 0.042$.)
Author (year)	Patient population Mean age ± SD (or range)	Study design and type of exercise	Main results
D. Atrial fibrillation in athletes			
Hoogsten et al. (2004) [30]	n = 30 (100% men) 48 ± 8 years Paroxysmal AF	Prospective cohort study 9-year follow-up Veteran athletes (running, cycling)	Paroxysmal AF continued in 50%, 17% developed permanent AF, and 23% were asymptomatic (no further AF at follow-up). Symptoms requiring termination of sports in 60% at baseline and 41% at follow-up
Myrstad et al. (2016) [31]	n = 140 (99% men) 69 (53–85) years 24% Permanent AF, 76% paroxysmal or persistent AF	Retrospective cohort study Veteran athletes (long distance cross-country skiing)	89% Physically active and 64% engaged in regular endurance exercise after the onset of AF

RCT, randomized controlled trial, HR heart rate, AF atrial fibrillation, peak VO₂ maximal oxygen uptake, QoL quality of life, ADL activities of daily living, MET metabolic equivalent of task, CV cardiovascular, OR odds ratio, HF heart failure, EF ejection fraction, NYHA New York Heart Association

activities. In a study of 140 veteran athletes (mean age 68.5 years) with AF who had participated in an annual 54-km cross-country ski race for an average of 17 (range 1–49) years, AF was paroxysmal or persistent in 76% and permanent in 24% [31]. AF was associated with poor subjective health and 32% reported reduced physical capacity as a result of AF, but two out of three reported that they had continued to practice regular endurance exercise even after the onset of AF.

Discussion

Data from the EORP-AF-registry indicate that regular exercise might be associated with reduced mortality and lower rates of cardiovascular endpoints, also in individuals with AF [27], and support that AF patients should exercise regularly to improve their cardiovascular risk profile. At the same time, there is a lack of data on the effect of exercise-based CR on mortality and serious adverse events [32], and weak evidence to support specific recommendations for exercise in individuals with AF. RCTs indicate that short-term exercise might improve exercise capacity by 10–16%, reduce symptoms and the burden of AF and improve QoL. However, the studies have a single-center design and included a relatively small number of patients. Furthermore, the selection of study participants reduces the generalizability of their results to the heterogeneous population of AF patients. Therefore, exercise recommendations should aim to be individualized. The suggested recommendations are based on our review of studies, knowledge about cardiovascular adaptations to exercise, and experience from clinical practice and research. Based on epidemiological data [27], we presume that AF patients will benefit from regular exercise in terms of reduced cardiovascular risk and mortality, and suggest exercise recommendations in line with cardiovascular disease prevention guidelines for the general population; A minimum of 150 min a week of moderate intensity (64–76% of peak HR) or 75 min a week of vigorous intensity (77–93% of peak HR) aerobic exercise or an equivalent combination thereof [8, 9]. The individual risk related to exercise depends on cardiovascular risk factors and co-morbid conditions, current physical activity level and the desired level of exercise intensity. Based on these factors, both the American College of Sports Medicine and the European Association of Cardiovascular Prevention and Rehabilitation recommend individualized exercise preparticipation evaluation to identify individuals with undiagnosed cardiovascular conditions and elevated risk of exercise-related sudden death and other cardiovascular events [33, 34].

First diagnosed atrial fibrillation

As AF can be the first symptom of underlying pathology, all patients with first diagnosed AF should be evaluated in line with existing guidelines [1], including ECG, echocardiography and thyroid function tests. Echocardiography should focus on LV size and function, valvular function, atrial sizes and right ventricular size and function. If an underlying cause of AF is detected, this should be treated properly, and exercise recommendations should be in line with specific guidelines for the underlying disease. If the evaluation does not reveal an underlying condition, we suggest that exercise with moderate intensity might be practiced without restrictions. In individuals with AF who intend to practice exercise or endurance sports with high exercise intensity, including veteran non-elite athletes, we suggest that the evaluation include a thorough history (family history of cardiac arrest or cardiac conditions, recent infectious diseases and drug use). Furthermore, we suggest that a stress test is performed in most individuals before high-intensity exercise is recommended. In individuals with high cardiovascular risk, patients using potentially proarrhythmic drugs such as flecainide (class IC-antiarrhythmics), and in previously sedentary or moderately active individuals, a stress test should be mandatory before high-intensity exercise.

Paroxysmal and persistent atrial fibrillation

We suggest that individuals with asymptomatic AF can exercise without restrictions after the suggested precautions. In individuals with major symptoms, treatment with flecainide, sotalol, dronedarone or amiodarone should be considered following recommended indications and contraindications [1]. Individuals using class-I antiarrhythmic drugs should be instructed to refrain from exercise until two half-lives of the drug have passed [35]. Patients with persistent symptoms or side effects on antiarrhythmic medication should be considered for AF ablation. In individuals with AF paroxysms induced by exercise, restrictions with respect to exercise intensity might be necessary. In the study by Malmo et al., high-intensity interval training reduced the arrhythmia burden in individuals with paroxysmal AF [17]. Exercise with high intensity (> 85% of peak HR) might have even larger cardiovascular benefits than exercise with moderate intensity and the results from this study support that exercise, even with high intensity, might be recommended as part of the treatment in this group of patients. On the other hand, prolonged endurance exercise seems to promote AF, probably due to atrial structural changes with increased volumes and myocardial fibrosis, and increased parasympathetic activity and enhanced atrial response to parasympathetic stimuli, as recently reviewed by Morseth et al. [36]. Research on

long-term effects and safety related to high-intensity exercise in AF patients is warranted.

Permanent atrial fibrillation

After the mentioned precautions, we suggest exercise without restrictions in individuals with asymptomatic permanent AF. Some patients with permanent AF could have incomplete ventricular filling with impaired cardiac output, or very rapid ventricular rates during exercise. This might reduce their exercise capacity and cause symptoms [37, 38]. Therefore, exercise restrictions might be necessary in some patients with high ventricular rates during exercise until sufficient rate control is achieved. On the other hand, our clinical experience is that many individuals with permanent AF have very high ventricular rates during exercise testing without any symptoms. As far as we know, there are no data suggesting harmful effect of asymptomatic rapid ventricular response to exercise in otherwise healthy individuals with AF. Exercise testing during AF might give valuable information on the ventricular rate and on symptoms during exercise, and be helpful to provide individualized exercise recommendations and optimize medical therapy. Beta-adrenoreceptor blocker monotherapy is the most common choice for rate control. The non-dihydropyridine calcium channel blockers verapamil and diltiazem are alternatives in patients with preserved left ventricular function.

Atrial fibrillation with underlying heart disease

For AF patients with underlying heart diseases, exercise recommendations will depend largely upon the underlying condition and if this is well treated. The beneficial effects of physical activity on cardiovascular risk factors are well established. Furthermore, beneficial adaptations in the heart and cardiovascular system are seen both during and after single bouts of endurance exercise and as a result of prolonged repeated exercise over months and years. Acute effects of exercise are mainly mediated through the sympathetic nervous system with positive chronotropic, inotropic and lusitropic effects on the heart. Prolonged repeated exercise increases cardiorespiratory fitness measured by peak oxygen uptake both in patients with sinus rhythm and AF [17, 39]. This is mainly due to increased cardiac output during exercise. Exercise induces physiological cardiac hypertrophy and increases contractility due to improved cardiomyocyte calcium handling [40, 41]. Data on exercise in individuals with AF and underlying heart diseases are very sparse, but risk factor intervention including regular exercise might reduce the symptom burden and cardiac remodeling in AF patients [42], and we believe that regular physical activity should be an important part of the treatment in AF patients with high cardiovascular risk. The RACE 3 trial supports

physical activity as part of a multi-component CR [29], but the exercise intensity in this study was low or moderate. Further studies are needed to evaluate long-term effects of different levels of physical activity and exercise in AF patients, including subgroups of AF patients with heart failure and other underlying conditions [28].

Atrial fibrillation in athletes

Data to support exercise recommendations in athletes with AF are very sparse, but both the Study Group on Sports Cardiology of the European Association for Cardiovascular Prevention and Rehabilitation, and the American Heart Association/American College of Cardiology have published general recommendations for competitive athletes [35, 43]. We believe that most athletes with paroxysmal AF can exercise without restrictions when in sinus rhythm. If symptoms occur during activity, it seems reasonable to cease the activity. It has been suggested that exercise restrictions should be the initial approach in young and middle-aged athletes with paroxysmal AF, to minimize the substrates and triggers for exercise-related AF [14, 35]. The positive association between endurance exercise and risk of AF might support detraining in athletes with AF. Furthermore, ectopic atrial foci can be activated by sympathetic stimulation and some AF patients experience atrial arrhythmias induced by exercise [44]. On the other hand, we are not aware of any studies that have prospectively addressed how exercise or detraining might influence AF burden, symptoms or the course of the disease over time in athletes with AF, or have demonstrated that AF in athletes is caused by cardiac remodeling that is reversible by detraining. Such studies are warranted, although challenging to complete. Thus, there is a lack of evidence that supports detraining as a general recommendation in athletes with AF, but in individuals with recurrent exercise-induced symptomatic paroxysms of AF, detraining for a period of 2–3 months might be considered [35]. In competitive athletes with recurrent AF, it can be difficult to ensure appropriate rate control during intensive exercise and medical treatment is challenging. Athletes with symptomatic AF should, therefore, be considered for AF ablation. Information regarding expected treatment effects and possible complications is mandatory.

Conclusions

Evidence for effects of physical activity and exercise in individuals with AF is sparse, but data from a few studies support beneficial effects in individuals with paroxysmal, persistent and permanent AF. We suggest that individuals with AF should exercise regularly after evaluation for underlying conditions. Recommendations should be individualized.

There is a lack of data to support exercise recommendations in athletes with AF. Further studies on long-term effects of physical activity and exercise are needed in all subgroups of AF patients.

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Compliance with ethical standards

Conflict of interest The authors report no relationships that could be construed as a conflict of interest.

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