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**Exercise-based Cardiac Rehabilitation for Patients with Atrial Fibrillation: A Narrative Review**

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**REVIEW**
*Arrhythmia and electrophysiology*

# Exercise-based cardiac rehabilitation for patients with atrial fibrillation: a narrative review

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The role of physical activity (i.e. any bodily movement that requires energy expenditure) and exercise (i.e. planned, structured, and repetitive physical activity to improve/maintain fitness) in the primary and secondary prevention of atrial fibrillation (AF) is increasingly recognized. Physical activity has been associated with lower risks to develop AF and associated complications (e.g. stroke, heart failure, and myocardial infarction). Exercise-based cardiac rehabilitation (ExCR) is increasingly examined in the treatment of AF and sometimes combined with rhythm control strategies (e.g. catheter ablation). Nonetheless, several important clinical, practical, and mechanistic questions remain not fully understood. This state-of-the-art review first provides a contemporary update on the evidence base for the clinical effects of ExCR in AF. Despite the ongoing need for high-quality studies, existing randomized controlled trials and cohort studies suggest ExCR reduces AF burden, lowers risks for major adverse cardiovascular events, and improves health-related quality of life. Second, to facilitate implementation of ExCR, we have observed comparable effects of distinct exercise protocols (e.g. type of training and centre-/home-based) and discussed similarity of effectiveness across patient characteristics (e.g. age, sex, and AF subtype). Critically, we have discussed potential barriers that may prohibit the uptake of ExCR for patients with AF, categorized at clinician- (e.g. referral and training), patient- (e.g. motivation, transportation, and psychosocial factors), and system-levels (e.g. insurance and resources). Third, we have summarized the potential mechanisms underlying these effects of ExCR, classified by their potential role in reducing AF burden (e.g. atrial/ventricular function, autonomic balance, and inflammation) and lowering risks for adverse events (e.g. modifiable risk factors, vascular function, and thrombogenesis). Based on the increasing evidence for clinical benefits, e.g. improved health-related quality of life and better clinical outcomes, we advocate stronger focus on regular physical activity and referral to multidisciplinary ExCR for sustainable lifestyle changes within the ESC AF-CARE pathway for the prevention and treatment of AF.

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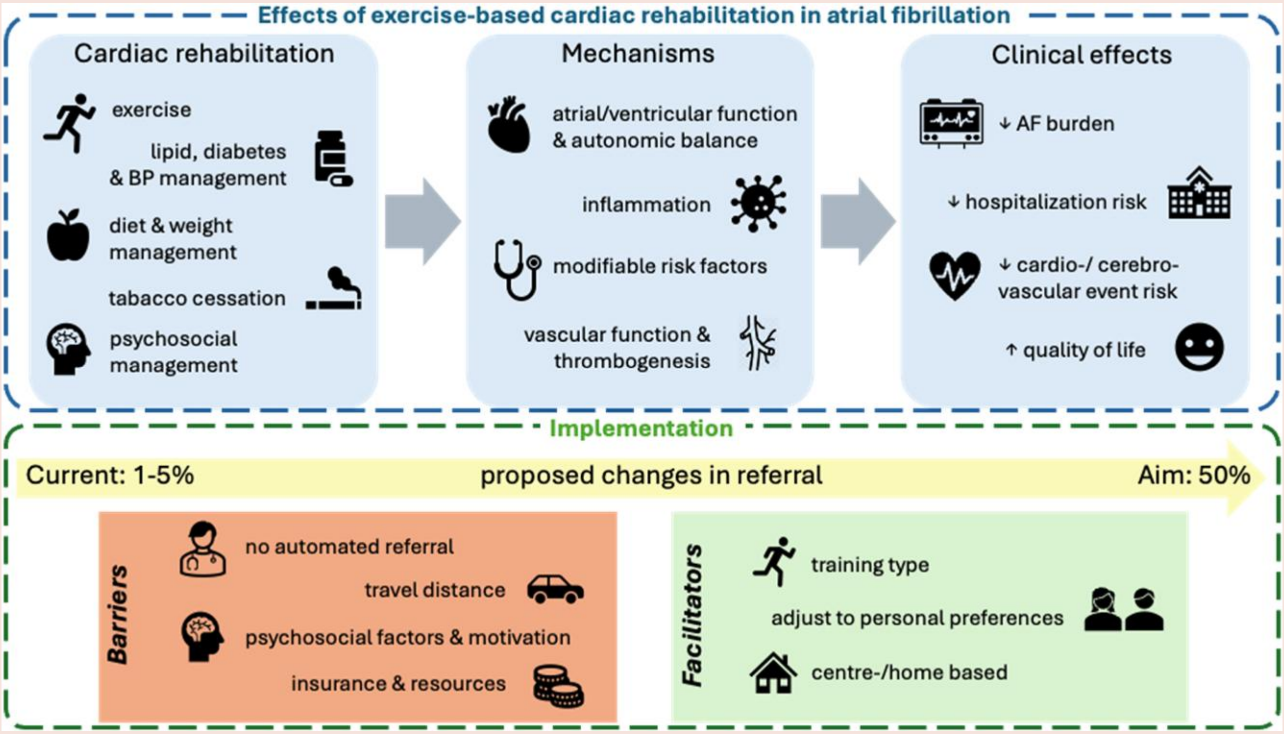
**Graphical Abstract**




**Keywords** Atrial fibrillation • Exercise • Physical activity • Pathophysiology

## What is the global burden of disease for AF?

Atrial fibrillation (AF) is the most common cardiac arrhythmia, with prevalence expected to rise exponentially within an ageing population.[1] The presence of AF is associated with increased risk for cardio-/cerebrovascular mortality and morbidity[2] and developing dementia,[3] but also associated with presence of anxiety and depression. Consequently, these health effects contribute to an impaired quality of life for patients with AF.

The management of AF has progressed to a more holistic or integrated care approach. The 2024 ESC guidelines propose the AF-CARE pathway (an acronym revision of the evidence-based ABC pathway[4]): [C] Comorbidity and risk factor management, [A] Avoid stroke and thromboembolism, [R] Reduce symptoms by rate and rhythm control, [E] Evaluation and dynamic reassessment.[5] The 2023 ACC/AHA/HRS/ACCP guidelines promote such holistic care as 'SOS'.[6]

Adherence to such multidisciplinary approaches has been associated with improved clinical outcomes,[7,8] leading to its recommendations in international guidelines. Nonetheless, residual risk of complications in patients with AF remains present, in addition to potential drug side effects, impact of comorbidities, relatively high post-ablation AF-recurrence rates, and high healthcare costs.[9]

An increasing number of studies explore the role of physical activity (PA; i.e. any bodily movement that increases energy expenditure) and exercise (i.e. planned, structured, and repetitive physical activity to increase or maintain fitness). Regular PA is well established to enhance cardiovascular health[10] and lower cardiovascular risk,[11] and is associated with a lower risk for AF.[12–14] Exercise-based cardiac rehabilitation (ExCR) is a multicomponent intervention that includes exercise training and PA promotion, but also health education, cardiovascular risk management, and psychological support. International guidelines in cardiology,[15] including the recent ESC guidelines for management of AF,[5] consistently give ExCR their highest recommendation (Class 1: treatment should be recommended) in the treatment of patients with myocardial infarction or following coronary interventions and heart failure.

The potential role of ExCR in AF has long been ignored, as supported by the remarkably low uptake of ExCR in patients with AF (0–5%).[16] In the past decade, an increasing number of studies have demonstrated potential benefits of ExCR,[17] which aligns within the current holistic AF-CARE pathway approach in treating AF. Although our understanding of ExCR in patients with AF has improved, many questions remain unanswered.

In this narrative review, we first provide a contemporary update on the evidence base for the clinical effects of PA and ExCR in AF. Second, to facilitate implementation of ExCR in AF, we will discuss optimization of exercise protocols, highlight between-group differences, and discuss potential barriers. Finally, we will summarize the mechanisms underlying these clinical effects, and provide recommendation for future work.

## Methodology

Although we have not adopted a pre-registered systematic review process, this narrative review was informed by prior systematic reviews. This review therefore included trials from a recent Cochrane systematic review of ExCR for adults with AF,[18] as well as two other, non-Cochrane systematic reviews investigating exercise-based CR or physical activity[19] and different types of exercise interventions[20] for people with AF.

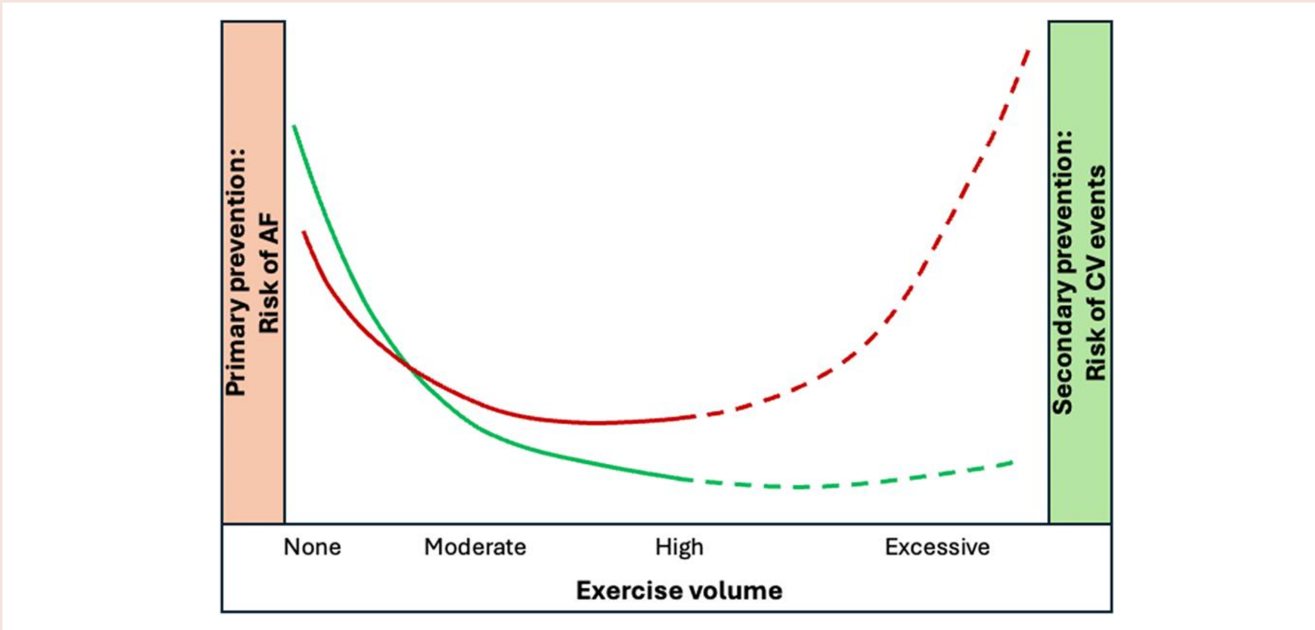



**Figure 1** Presentation of the dose–response relationship between the volume of exercise and the primary [red line (line starting at the lower point on the left): risk of AF in general population] and secondary prevention [green line (line starting at the higher point on the left): risk of AF recurrence and CV events] in relation to atrial fibrillation. Moderate and high exercise volumes reflect meeting 1–2 or 3–4 times the WHO guidelines on physical activity, respectively. The dashed line represents the hypothetical part on the risks associated with excessive volumes of exercise, for which relatively few studies have provided insight.

Building on the methodology outlined in these reviews, we included both original trials from the Cochrane review and additional prospective and retrospective studies published that examined the impact of exercise or physical activity on health outcomes for people with AF. Second, we have used the following search strings 'physical activity OR exercise OR sport*' and 'exercise-based cardiac rehabilitation OR cardiac rehab* OR rehab*' to ensure any other contemporary studies were considered.

# Role for physical activity and exercise in AF

## Is physical activity related to the primary prevention of AF?

Emerging evidence linked regular PA engagement to the primary prevention of AF, with even light-to-moderate-intensity PA being associated with lower AF incidence.[12] A meta-analysis including 22 case–control and observational studies ($n = 656\,750$)[21] revealed that an 'inactive lifestyle' was associated with a 2.5-fold increased lifetime risk of developing AF, a risk that was independent of sex. In a recent UK Biobank cohort analysis ($n = 402\,406$), Elliott *et al.*[13] found that achieving >1500 MET-min/week (metabolic equivalents) of activity was associated with a 15% lower risk of incident AF vs. no activity. Lower risks for incident AF in relation to regular PA have also been observed in those with disease (e.g. type 2 diabetes).[22]

## How is the spectrum of physical activity related to AF development?

The observation that regular PA is protective for incident AF also raises questions regarding its dose–response relation. Below, we have addressed this topic by discussing the potential negative effects of sedentary behaviour and excessive endurance training, but also the impact of sex differences (Section 2.2). Despite the potentially complex nature of the dose–response relationship between PA, exercise, and AF, the majority of studies suggest beneficial effects in the primary prevention of AF when adopting or modestly exceeding (2–3 times) current guideline levels (*Figure 1*).

### Sedentary behaviour

Although high volumes of sedentary behaviour (e.g. activities at low energy expenditure in a sitting or lying position) increase risks of cardiovascular mortality and morbidity,[23] few have examined this in the context of AF. A previous study in 14 458 adults reported that greater frequency of TV watching was associated with an increased risk of AF.[24] However, TV watching is a poor proxy for sedentary time. A more recent study, using accelerometry in older women, found that the most sedentary quartile (11 h/day) showed a HR of 2.19 for developing AF compared to the least sedentary quartile (7.3 h/day), but this effect disappeared when controlling for PA.[25]

### Extreme volumes of exercise

With the growing popularity of endurance exercise, there is a lively debate whether high volumes of exercise may be detrimental to cardiovascular health.[26] Regarding AF, there seems consensus that high volumes of endurance exercise are associated with a counterintuitive increased risk for AF.[27] A previous meta-analysis and meta-regression[28] revealed 2.46 increased odds of AF in athletes compared to non-athlete controls. Whilst meta-regression suggested those participating in mixed sports demonstrated the highest risk for AF, others suggest that specifically endurance exercise is associated with the highest risk.[29] In addition, Morseth *et al.*[30] found that participating in vigorous-intensity PA diminishes beneficial effects of regular walking/cycling on risk of incident AF. A lack of prospective study of objective exercise volume and AF occurrence makes it difficult to truly understand and identify factors interacting with this increased risk. Nonetheless, an important observation is that sex may interact with the risk of AF in relation to high levels of physical activity. Based on self-reported physical activity levels in 402 406 individuals from the UK Biobank cohort, Elliott *et al.*[13] reported that excessive volumes of vigorous physical activity are associated with incident AF in men, but not in women. Future studies are warranted to better understand these observations, including understand the potential underlying reasons. Taken together, despite these observations of an increased risk of AF with excessive exercise, these volumes far exceed existing guidelines and it appears to take years of training for such elevated risk.

## What is the effect of exercise-based cardiac rehabilitation in AF?

### Randomized clinical trials

Although being a core component, ExCR goes beyond exercise training alone and also targets other lifestyle factors, including smoking, overweight/obesity, and excessive alcohol intake. A recent Cochrane systematic review and meta-analysis with meta-regression included 20 randomized clinical trials (RCTs) investigating the effects of ExCR compared to exercise control for participants with AF ($n = 2039$).[18] There was high heterogeneity in trial intervention length (8–52 weeks), frequency (1–7 sessions/week), and length (15–90 min/session). Exercise type consisted of aerobic exercise at either light-, moderate-, or high-intensity, a combination of aerobic- and resistance-based training. Four studies investigated non-traditional exercise programmes, including Qi-gong, inspiratory muscle training, and yoga.

Meta-analysis showed little to no difference in all-cause mortality between ExCR and control groups [relative risk (RR) 1.06, 95% confidence interval (CI) 0.76–1.49] and serious adverse events (including any untoward medical occurrence that was life-threatening, resulting in death, or that was persistent or leading to significant disability or hospitalization) (RR 1.30, 95% CI 0.63–2.67). However, the certainty evidence of these outcomes was rated low due to limited number of events and trials contributing to the effect estimate. An important caveat is the limited follow-up duration within most included trials, as clinical outcomes may occur later in life. We therefore strongly recommend future studies to include a sufficiently long follow-up period to understand the potential of ExCR on adverse clinical endpoints.

ExCR was associated with reduced AF recurrence (RR 0.70, 95% CI 0.56–0.88) and patient-reported AF symptom severity and burden. This supports prior epidemiological work suggesting a beneficial role of exercise in managing AF.[31] To extend this observation, the Cochrane review showed improvements in health-related quality of life for those undergoing ExCR in the mental health subscale, but not the physical. Nonetheless, measures of exercise capacity (e.g. peak oxygen uptake and 6 min walk test) showed statistically significant (and clinically meaningful) improvements following ExCR.

One trial included in the Cochrane review was performed by Elliott *et al.*[32] who randomized 120 patients with symptomatic paroxysmal or persistent AF to a tailored exercise and physical activity intervention or control group (i.e. educational sessions about physical activity). This trial showed improvements in exercise capacity and quality of life (QoL) following ExCR, but also a significant reduction in objectively measured AF recurrence. In support of these clinical effects of ExCR, Malmo *et al.*[33] focused on the short-term effects of high-intensity aerobic interval training and demonstrated a significant reduction in AF episodes. A more recent RCT compared high-intensity interval training vs. moderate-intensity continuous training (MICT) in 86 participants with AF. Despite a substantially lower total exercise volume, the authors found that high-intensity interval training was as efficacious as moderate-intensity training in improving functional capacity, quality of life, resting heart rate, and physical activity levels.[34] Another study by Luo *et al.*[35] examined the long-term effects of ExCR on outcome of cardiovascular death and heart failure hospitalization. They highlighted the potential of ExCR in reducing severe cardiovascular events, although the difference in mortality was not statistically significant and underpowered.

### Cohorts

In a cohort study conducted by Pathak *et al.*,[36,37] it was found that greater cardiorespiratory fitness (CRF) was associated with increased freedom of AF and for every 1 MET increase in CRF (via exercise training), AF recurrence was reduced by 9%. Similarly, in >64 500 adults, Qureshi *et al.*[38] observed that every 1 MET increase in CRF was associated with a 7% lower risk of incident AF. More recently, Garnvik *et al.*[39] collected self-reported PA and estimated CRF in 1117 patients with prevalent AF over ∼8 years. Primary findings showed that meeting the guideline 150 min/week of moderate-intensity PA resulted in a 45% and 50% lower risk of all-cause and cardiovascular disease mortality, respectively, in comparison to those who were inactive. In addition, each 1 MET increase in CRF was associated with 12% lower all-cause mortality and 15% lower cardiovascular disease mortality. Even achieving less than the guideline PA levels associated with a lower risk of mortality compared with inactive patients, advocating that, even below the recommended levels of PA, some PA is better than nothing for secondary prevention of AF.

In a large cohort study including >66 000 patients with a recent diagnosis of AF, it was found that those who initiated exercise following their diagnosis, or maintained MICT, had lower rates of heart failure, stroke, and mortality.[40] Similar observations were found in the HUNT3 study[39] where it was observed that patients with AF who engaged in MICT had lower long-term risks of all-cause mortality and cardiovascular disease in comparison to the non-exercise group. Finally, recent epidemiological studies have shown that ExCR associates with significantly lower risk of clinical events and morbidity,[41] as well as lower risk for AF progression vs. matched controls.[31]

Collectively, cohort studies and RCTs investigating ExCR for patients with AF support its use as a valuable component of comprehensive AF management.[42] Beneficial effects have been reported on AF recurrence, exercise capacity, and QoL, though the impact on clinical events (e.g. mortality and serious adverse events) remains uncertain. The evidence base, whilst promising, requires further high-quality RCTs with standardized protocols and longer follow-up periods to confirm the role of ExCR in AF treatment paradigms, and may identify exercise modalities and intensities that yield the most significant benefits for AF patients and any difference in subgroups to aid personalization and widen options for patients.

# Implications for clinical guidance and implementation

## Are benefits consistent across patient and intervention characteristics?

### Patient characteristics

Whilst individual RCTs are underpowered to assess the impact of patient characteristics, the Cochrane systematic review of ExCR for AF ($n = 2039$) showed the benefits of ExCR were consistent across different patient characteristics including age, sex, AF subtype (paroxysmal/persistent/permanent), and catheter ablation treatment. Sufficiently powered RCTs and/or individual patient data meta-analytical approach may assist in better understanding the role of patient characteristics.

### Exercise characteristics

Based on frequently studied cardiovascular conditions, meta-regression indicates that total energy expenditure of an exercise programme is the strongest predictor for an increase in exercise capacity.[43] Methodological limitations of existing studies (e.g. sample size, lack of follow-up, and limited variation in exercise volumes) prohibit a valid evaluation of this in AF. Over the years, high-intensity interval training has received substantial attention as a time-efficient and potentially effective strategy in cardiac rehabilitation (see review).[44] Studies examining the impact of high-intensity interval training (~1 h/week) in patients with AF have revealed its potential to reduce AF burden.[33] However, both high-intensity interval and MICT seem equally effective to improve fitness and disease-specific outcomes.[34] Taken together, there is currently no strong evidence that one type, mode, and/or intensity of exercise is superior (at group level) in patients with AF.

### Home- vs. centre-based

Due to recent advances in technology, partly accelerated by the SARS-CoV-2 pandemic, remote digital support is an expanding approach. A large systematic review with meta-analysis (96 studies) concluded that telemonitoring was an effective intervention, reducing mortality and improving self-management of the disease, with patients reporting good satisfaction and adherence.[45] A recent Cochrane review (24 trials; $n = 3046$) found comparable benefits of home- vs. centre-based ExCR in all-cause mortality (12 months follow-up) and health-related quality of life (24 months follow-up).[46] Whilst it seems crucial to consider the risks and pitfalls of these wearables, these observations together support the ongoing use of digital health (e.g. wearables) to support remote delivery in treatment of AF.

## What are current barriers preventing wider implementation?

Despite the strong evidence supporting benefits of ExCR and international clinical guidelines recommending ExCR participation, uptake of ExCR in eligible patients is low.[16] Whilst barriers are likely interrelated, studies have categorized barriers of ExCR uptake according to clinician-, patient-, and health system-level factors (*Figure 2*). Although evidence on ExCR uptake in AF is scarce, and uptake in AF is amongst the lowest of cardiovascular diseases (<1–5%),[16] it appears that barriers are comparable to those seen in coronary heart disease (CHD) and heart failure (HF) patients.[47]

### Healthcare professional-level

One potential barrier relates to the relatively few studies examining, and subsequently supporting, the effects of ExCR in patients with AF. This specifically relates to sufficiently powered RCTs with long-term follow-up to establish the clinical benefits of ExCR, and identify strategies to optimize the timing and content of the exercise protocol for AF. Indeed, prescription to ExCR is not specifically mentioned in ABC-pathway or AF-CARE model.[5] Furthermore, presence of AF is associated with lower referral rates to ExCR in those with coronary artery disease. This highlights the need to improve education about the effects of PA in AF, during both general medical and cardiology training. Another potential solution relates to adopting an automated referral system combined with a patient discussion, as such approaches lead to superior referral rates (review),[48] with increases up to 45%.[49]

### Patient-level

Multiple patient-level factors have been identified, with non-referral being more common with older age, female, frailty, and multimorbidity.[16] Interestingly, studies in frail patients with heart failure revealed cardiac rehabilitation to be effective, if not superior compared to non-frail participants.[50] This suggests that benefits of ExCR are robust and seem present across (sub)groups. The distance to the rehabilitation facility is another frequently reported patient-level barrier,[16] for which remote home-based rehabilitation seems a feasible and potentially successful facilitator. Other relevant patient-level barriers relate to time restrictions and lack of motivation. Pertaining to these barriers, we reported that clinical benefits seem equally present across exercise protocols, but also between centre- vs. home-based rehabilitation (Section 2.1). This allows to acknowledge patients' personal barriers and/or preferences.

A final patient-related barrier relates to psychosocial factors, including caregiver support, socioeconomic status, and self-efficacy. Indeed, a recent Cochrane review reported potential for positive effects for social network and social support interventions, but also highlighted the lack of sufficient evidence for conclusive support.[51]

### System-level

Previous work indicated that insufficient personnel and facilities represent an important system-level barrier to prescribe ExCR in low- and middle-income countries (review),[52] whilst high-income countries also experience this barrier. Another system-level factor is the variation in insurance systems, which unfavourably affects lower socioeconomic groups. To highlight its complexity, even in countries where ExCR is financially covered, lower income is associated with lower referral rates.[16]

# Mechanisms explaining the benefits of exercise for AF

## What mechanisms are likely related to AF burden or recurrence?

### Atrial remodelling

Pathological changes in atrial structure (e.g. enlarged and fibrosis) and function (e.g. lower reservoir and strain) are associated with development and progression of AF, whilst atrial function seems strongly related to exercise intolerance.[53] Whilst left ventricular adaptation is widely examined, only few studies explored the effects of exercise training on atrial health (review).[54] Regarding atrial fibrosis, i.e. a central proponent of the atrial arrhythmogenic phenotype, endurance training unlikely reverses this process.[55] Alternatively, weight loss and exercise training may promote reversal of atrial enlargement in patients with AF.[56] Furthermore, exercise training has also been linked to improved left atrial function.[33] However, despite the reductions in AF burden, not all training studies in AF report atrial adaptations.[32] These findings suggest that exercise training in patients with AF can contribute to atrial remodelling, but this is not a prerequisite for clinical benefits.[54]

### Autonomic imbalance

The activity of the autonomic nervous system plays a crucial role in the pathogenesis of AF. Several meta-analyses have evaluated the effects of exercise training in various populations with cardiovascular disease or risk on autonomic balance, with heart rate variability a popular outcome. Whilst these meta-analyses emphasize a lack of robust clinical studies, most report the ability of exercise training to improve autonomic balance.[57] In patients with AF, exercise training seems to lower resting heart rate[58] and increase heart rate variability, the latter indicative for increased vagal tone.

### Inflammation

In line with other cardiovascular diseases, presence of inflammation is a well-established risk factor for the development of AF. The effects of exercise on inflammatory markers are complex with conflicting results. This may, at least in part, be related to the duration (acute vs. chronic), intensity, and volume of exercise.[59] Regular PA or exercise, not

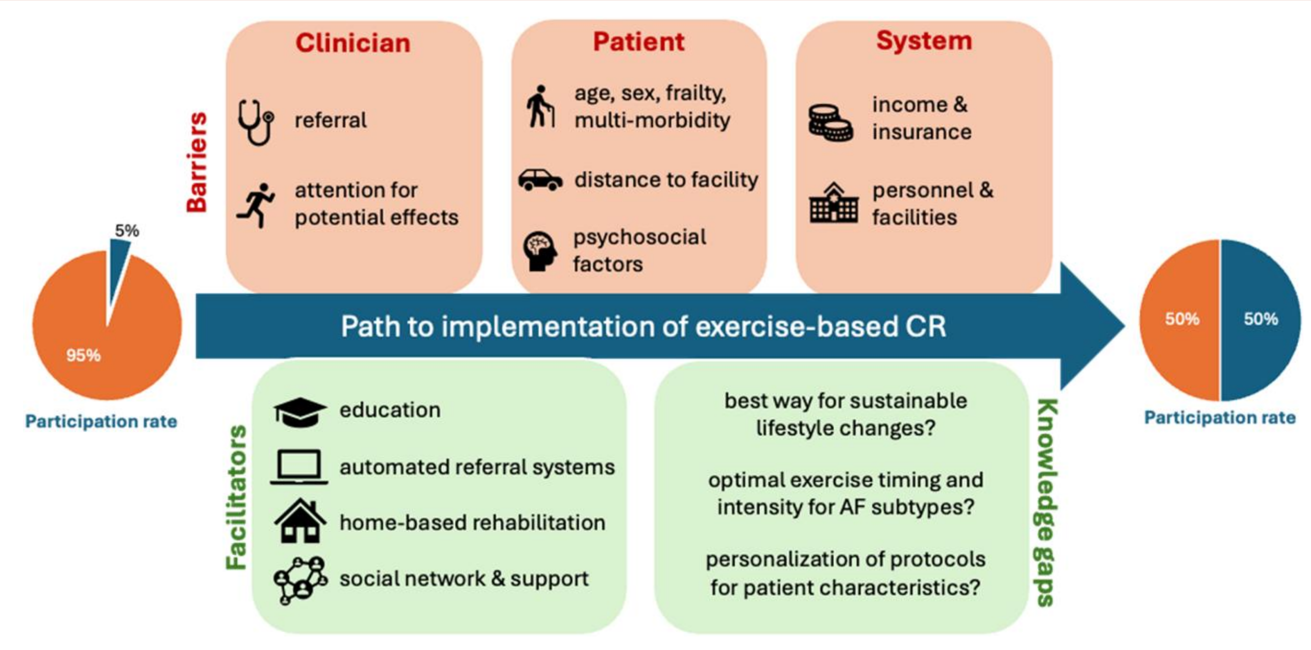



**Figure 2** Presentation of barriers (top) and facilitators + future direction (bottom) for the wider implementation and referral to ExCR in patients with AF. Barriers for implementation have been categorized into factors related to the clinician, patient, and system. The current and proposed participation rate target has been presented in the middle.

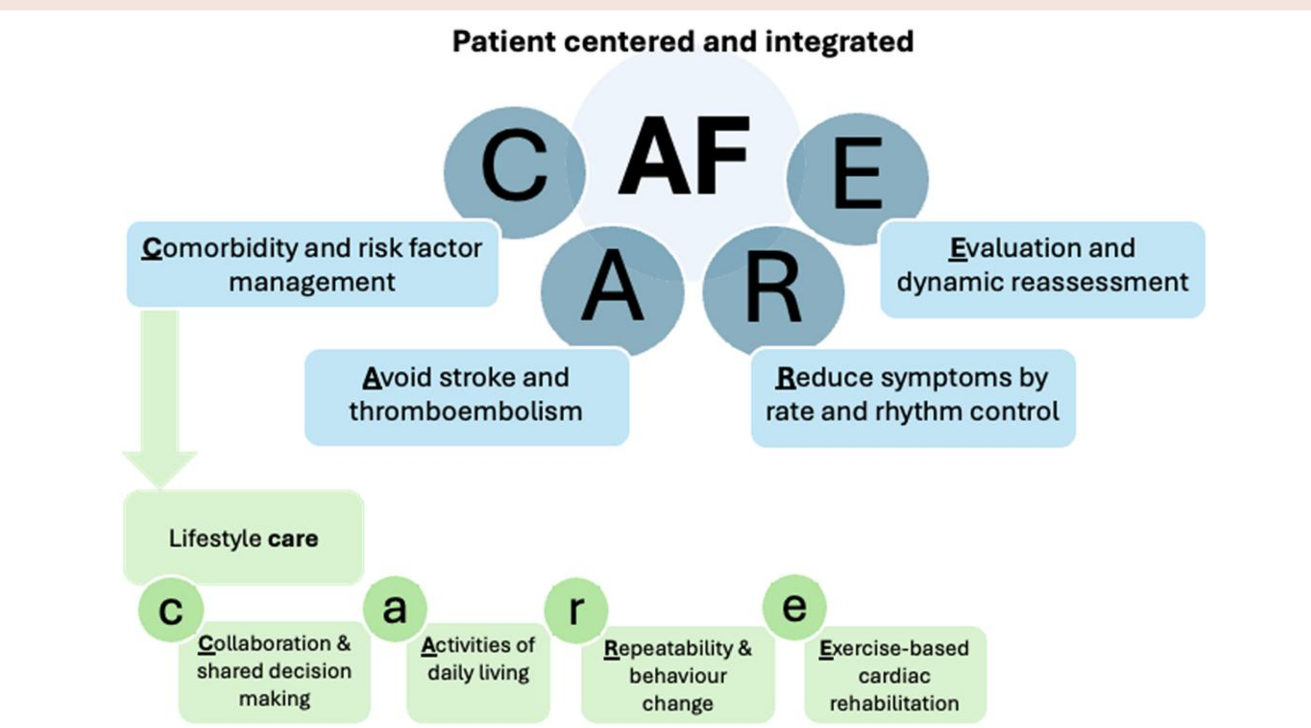



**Figure 3** Presentation of the holistic AF-CARE pathway in the treatment of AF, with expansion of the comorbidity and risk factor management ('C'), with specific focus on the promotion of an active lifestyle. Specifically, we have highlighted four key pillars to promote an active lifestyle following the 'lifestyle-care' pathway; [c] collaboration for shared-decision making, [a] activities in daily living, [r] repeatability in engaging in this lifestyle for sustainable changes, and [e] exercise-based cardiac rehabilitation.

performed at excessive intensity/volume, seems associated with the suppression of pro-inflammatory cytokine production, enhancing anti-inflammatory mediators, antioxidant development, and promoting fibrinolytic activity.[60]

## What mechanisms are likely related to clinical events?

### Traditional cardiovascular risk factors

The pathogenesis of arrhythmia and development of clinical events is strongly related to traditional cardiovascular risk factors. This includes hypertension, dyslipidaemia, obesity, smoking, low fitness, and diabetes mellitus (review).[61] Engagement in regular PA is demonstrated to improve risk factors, which, at least partly explains the benefits of PA in protecting against cardiovascular events. To reinforce these observations in AF, Pathak *et al.*[37] examined the effects of a structured exercise programme in 308 participants with AF, and found improvements in traditional cardiovascular risk factors. Moreover, they also demonstrated significantly larger effect sizes in those who improved their fitness the most[37]; suggesting that clinical benefits from exercise training relate to improvements in fitness and risk factors.

### Endothelial function

Through their direct effects on the endothelium, risk factors and inflammation may contribute to developing AF (and clinical events) through endothelial dysfunction. Indeed, patients with AF demonstrate an impaired endothelial function,[62] whilst measures of vascular health independently predict AF. Regular PA is well established to improve vascular function and structure, most likely through the repeated exposure to haemodynamic stimuli (e.g. shear stress).[10] Supporting this hypothesis, a recent RCT ($n = 74$) evaluated the impact of 6–12-month exercise training in patients with AF and found improvements in blood biomarkers of endothelial function.[63]

### Thrombogenesis

The prothrombotic state in AF, strongly related to development of stroke and thromboembolism, occurs as a consequence of multifaceted interactions known as Virchow's triad of hypercoagulability, arterial abnormalities, and intra-atrial stasis. In addition to the impact on arterial abnormalities (see 'endothelial dysfunction'), PA and exercise in patients with cardiovascular disease,[63] including AF,[64] are able to affect the other components of Virchow's triad, e.g. platelet function and thrombogenic factors.[63,64]

Taken together, potential mechanisms underlying the effects of regular exercise and physical activity primarily relate to (i) reducing AF burden or recurrence, or (ii) lowering risks for clinical events (*Figure 3*). Nonetheless, some mechanisms likely show interaction effects and, therefore, contribute to both endpoints (e.g. inflammation and risk factors). Future prospective studies are warranted to truly understand these underlying mechanisms in AF.

## Future directions

The evidence supporting benefits of ExCR for people AF is increasingly promising and includes reduction in AF burden and cardiovascular risk, and improvement in health-related quality of life. Nonetheless, definitive evidence is needed through well conducted multicentre RCTs adequately powered to evaluate relevant clinical outcomes. Future trials should also address the following questions: optimal timing of ExCR prescription (e.g. ablation), cost-effectiveness of ExCR, and AF populations who benefit from ExCR (e.g. AF subtype, sex, and frailty) (*Table 1*). Furthermore, at the patient-level, we anticipate that current advances in digital health for home-based treatment alleviate several barriers (e.g. transportation, time constraints, and individual supervision). Moreover, the robust effects across various exercise protocols allow for personalized treatment programmes (e.g. patient preferences and facilities). We recommend multiple strategies, rather than a single 'silver bullet', for successful clinical implementation.

There are also substantial challenges in implementation of ExCR in current clinical treatment of AF. Acknowledging the complexity and interaction of the various barriers, we highlight the potential of automated referral combined with patient instruction. This may require integration of ExCR in treatment guidelines. Despite the undisputed benefits of the integrative multidisciplinary pathway in treating AF, relatively little attention is present on *promoting* lifestyle changes and strategies to achieve these. Therefore, aligned with C (comorbidity and risk factor management) being listed as the first element of the AF-CARE model (*Figure 3*),[5] we propose clinicians to more strongly focus on the promotion of physical activity and exercise for people with AF. This is particularly timely with the recent Cochrane findings and 2024 ESC guidelines giving a Class-I recommendation for tailored exercise programmes. Specifically, we have highlighted four key pillars that seem crucial to promote an active lifestyle following the 'lifestyle-care' pathway; [c] collaboration for shared-decision making, [a] activities in daily living, [r] repeatability in engaging in this lifestyle for sustainable changes, and [e] exercise-based cardiac rehabilitation (*Figure 3*).

**Table 1 Summary of findings**

| **Key findings** |
|---|
| Regular physical activity (PA) lowers the risk of developing AF, with even light-to-moderate-intensity PA showing protective effects.[13] |
| Exercise-based cardiac rehabilitation (ExCR) reduces AF burden and AF severity, improves health-related quality of life, and enhances exercise capacity.[18] |
| Both high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) appear effective for AF patients.[34] |
| Home-based ExCR appears as effective as centre-based programmes, supporting remote delivery for CVD patients in general.[46] |
| Barriers to ExCR uptake exist at clinician, patient, and system-levels, contributing to low referral and adherence rates for patients with CVD in general (*Figure 2*). ExCR is not yet indicated for patients with AF, yet tailored exercise is given a Class-I recommendation in the latest ESC guidelines.[65] |
| Gaps for future research |
| Need for large, multicentre RCTs with long-term follow-up to confirm clinical event reduction from ExCR, as suggested in cohort data.[19,41] |
| Optimal timing and intensity of ExCR prescription for different AF subtypes remain unclear. |
| Cost-effectiveness and economic burden of implementing ExCR in AF patients require further study and whether certain subgroups should be prioritized. |
| Personalization of exercise protocols based on patient characteristics (e.g. sex, frailty, and AF subtype) is not well understood. |
| Effectiveness of mobile health interventions and remote monitoring for ExCR implementation needs further validation in patients with AF. |
| Role of ExCR in combination with pharmacological and rhythm control strategies (e.g. ablation) remains to be fully explored. |
| Longitudinal studies needed to understand dose–response relationships of PA in AF patients. |

In conclusion, based on the increasing evidence for PA and exercise leading to clinical benefits, we advocate for future research and consideration of ExCR within the multidisciplinary holistic or integrated care management pathways to enhance its implementation.

# Lead author biography

Dr Benjamin J.R. Buckley is a Senior Lecturer at the Liverpool Centre for Cardiovascular Science and a Fellow of the European Society of Cardiology. His research focuses on preventive cardiology, with expertise in cardiovascular epidemiology. He is particularly interested in the role of lifestyle in preventing and managing chronic conditions, as well as brain-heart interactions. Beyond academia, he enjoys spending time in nature, particularly trail running and climbing.

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## Data availability

No new data were generated or analysed in support of this research.

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