



# Effects of high intensity exercise on the heart

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*Regular exercise provides a range of health benefits including improved cardiovascular health. However, there is mounting evidence to suggest that highly trained athletes are at greater risk of some arrhythmias such as atrial fibrillation.*

## Key points

- **Exercise is one of the most powerful positive therapies for improving cardiovascular and overall health.**
- **Regular exercise training results in functional, electrical and structural changes in the heart (the 'athlete's heart'), which is almost always benign.**
- **The extent of heart changes is proportional to an athlete's fitness.**
- **Some arrhythmias, such as atrial fibrillation, are slightly more common in endurance athletes. The causes and treatments specific to athletes are yet to be determined.**
- **People should be encouraged to take up regular exercise regimens. The manner in which they start their exercise regimens (preferably gradually and consistently) is probably more important than any pre-participation screening. Anyone developing symptoms during exercise should be assessed promptly and thoroughly.**

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**R**egular exercise provides major health benefits. The major cardiovascular and noncardiovascular benefits provided by regular moderate exercise are summarised in Figure 1.<sup>1</sup> Exercise represents a 'super pill' with the potential to address many of the most prevalent health burdens of modern society. However, like any pill there is also at least a theoretical concern about toxicity.

Over the past few decades, accumulating evidence suggests that highly trained athletes are at greater risk of some arrhythmias such as atrial fibrillation.<sup>2</sup> We are only starting to understand this paradox: how much exercise might be too much, who is at risk, and how do we treat these health complications among the fittest members of society? It is also extremely important to maintain perspective because these health concerns are minimal compared with the vast and unequivocal benefits of exercise.

## How does the heart change with intense exercise?

In both men and women, regular strenuous exercise training promotes structural, functional and electrical remodelling of the heart termed 'athlete's heart' (see Figure 2). The volumes and wall thickness of all four heart chambers enlarge and this enables the heart to pump more blood with every beat and thus athletes are able to pump greater volumes of blood to the muscles during exercise. This is one of a number of adaptations that enables athletes to consume greater amounts of oxygen and generate greater amounts of energy during exercise. Thus cardiac enlargement is a performance-enhancing trait, with larger heart size correlating quite strongly with fitness conditioning (see Figure 3).<sup>3</sup> This provides some indication as to how much cardiac remodelling (athlete's heart) may be expected. As a rough rule of thumb, if an individual has cardiac enlargement that is suspected to be due to exercise then he or she would be training regularly (three hours or more per week) and be very fit. Fitness can usually be ascertained on history but, if necessary, can be confirmed by formal exercise testing.

In addition to heart enlargement, the heart's function improves with an enhanced ability to pump very large volumes during exercise and, even more importantly, to rapidly fill during exercise.<sup>4</sup> Finally, electrical remodelling of the athlete's heart can cause

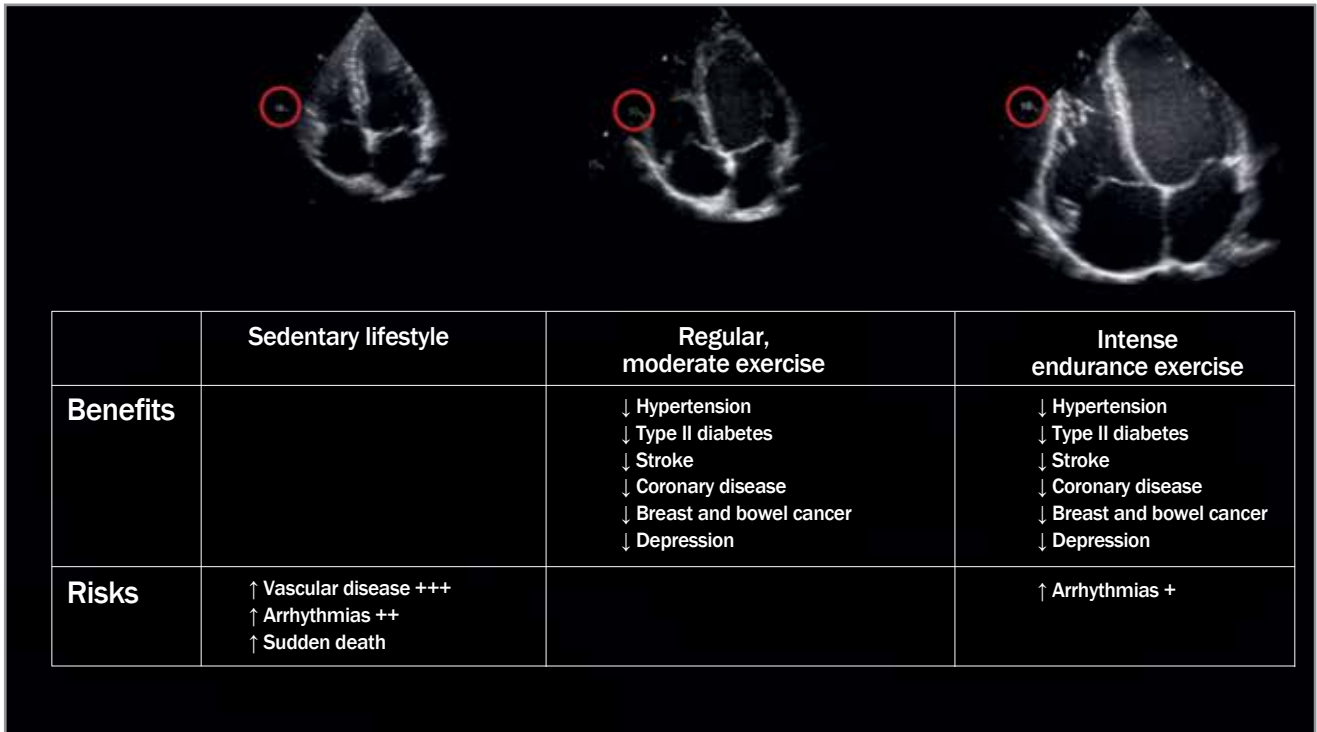


Figure 1. Benefits and risks of exercise. There are substantial health benefits associated with regular exercise compared with a sedentary lifestyle. These benefits are mostly maintained in endurance athletes; however, there may be a small increase in some arrhythmias. This small increase in arrhythmias may relate to the profound changes that can occur in cardiac structure in response to exercise training. The red circle in the images highlights the 1.0 cm depth marker on ultrasound, which has been used to approximately scale the cardiac echocardiographic images. Put simply, the athlete's heart can increase three- or four-fold the size of nonathletes.

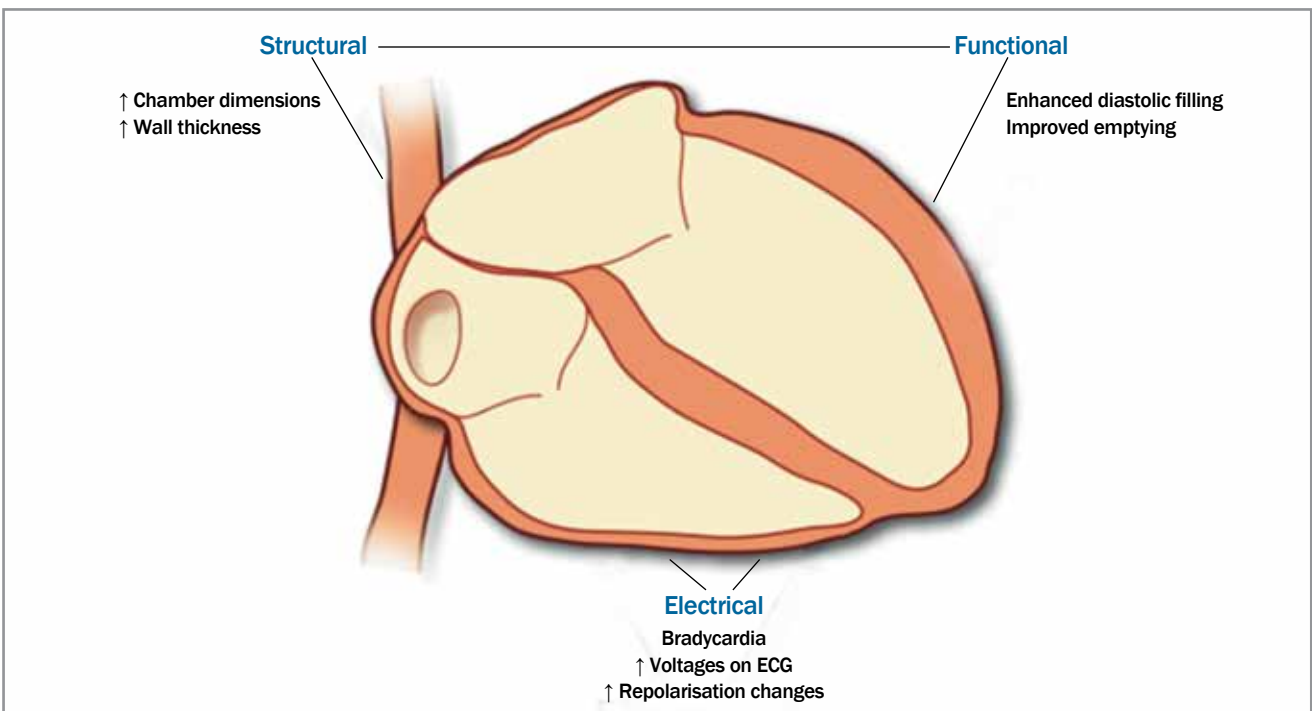
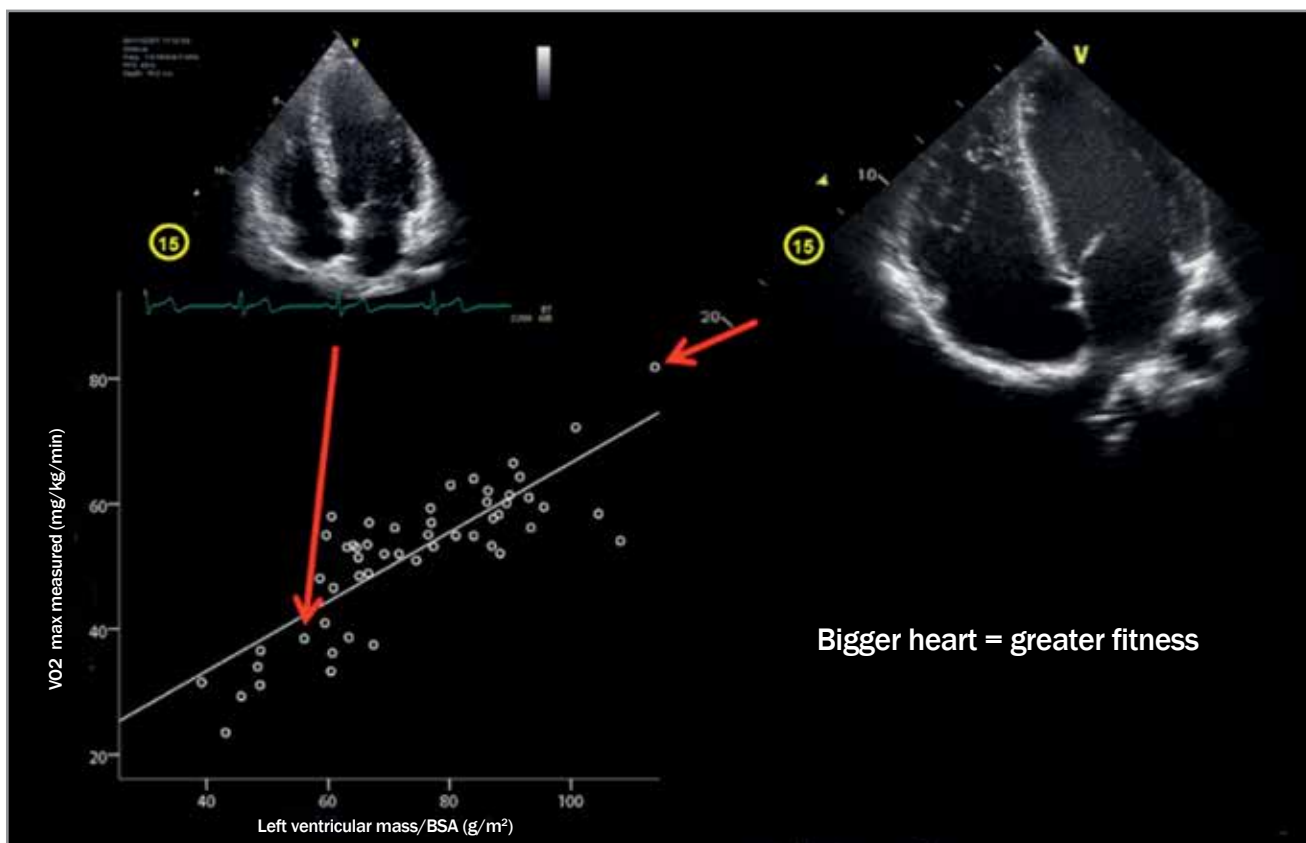


Figure 2. The athlete's heart. Regular intense exercise training results in structural, functional and electrical changes in the heart.



**Figure 3. Relationship between heart size and fitness. A strong correlation between VO2 max and cardiac mass suggests that the fitter you get, the greater the changes in heart size, function and electrical remodelling.<sup>3</sup>**

Abbreviations: BSA = body surface area; VO2 = maximal oxygen uptake.

Modified from: La Gerche A, Burns AT, Taylor AJ, Macisaac AI, Heidbüchel H, Prior DL. Maximal oxygen consumption is best predicted by measures of cardiac size rather than function in healthy adults. *Eur J Appl Physiol* 2012; 112: 2139-2147.<sup>3</sup>

distinct changes in the electrocardiogram (ECG), most of which are common and benign (sinus bradycardia, sinus arrhythmia or first degree atrioventricular block) but some of which deserve further assessment as they may be an indication of underlying heart disease. T-wave inversions, Q waves, left bundle branch block or advanced heart block all require further testing.

There has recently been considerable debate as to whether ECGs should be used to screen athletes before sports participation. This is a complex debate with nuances that are specific to the Australian demographic.<sup>5</sup> The role of pre-participation assessment is also topical in those seeking to undertake a new intense exercise regimen, such as the recently promoted high intensity interval training. Australasian guidelines, which are currently in development, should encourage people to perform daily exercise of at least moderate intensity. The safest approach is to gradually build intensity and duration of exercise while medical evaluation should be directed at those who experience any symptoms during this process (in preference to broad-based screening). In this manner, the enormous health benefits of exercise can be realised with maximal safety.

### Why is the athlete's heart important?

There are two main clinical settings in which cardiac remodelling becomes of clinical importance. The first is that the cardiac hypertrophy can resemble inherited cardiomyopathies, such as hypertrophic, dilated and arrhythmogenic cardiomyopathies. This assumes great importance when one considers that strenuous exercise is a recognised trigger for sudden cardiac death in patients with underlying heart disease. Thus, correct diagnosis becomes critical so that athletes with exercise-induced cardiac remodelling can be reassured, whereas those with a cardiomyopathy need to be advised to restrict activity.

More controversially, there is evolving recognition that athlete's heart may not be entirely benign. As summarised in Figure 4, arrhythmias are more common in well-trained athletes.<sup>2,6-11</sup> In most cases, these arrhythmias are relatively benign. Biffi and colleagues have demonstrated that ventricular ectopic beats are very common in athletes and seem to increase and decrease with training and detraining, respectively.<sup>8</sup> Slightly more problematic is the approximate five-fold increase in risk of atrial fibrillation, which is most apparent in middle-aged and older athletes, particularly among male athletes.<sup>6</sup> The most controversial topic is whether

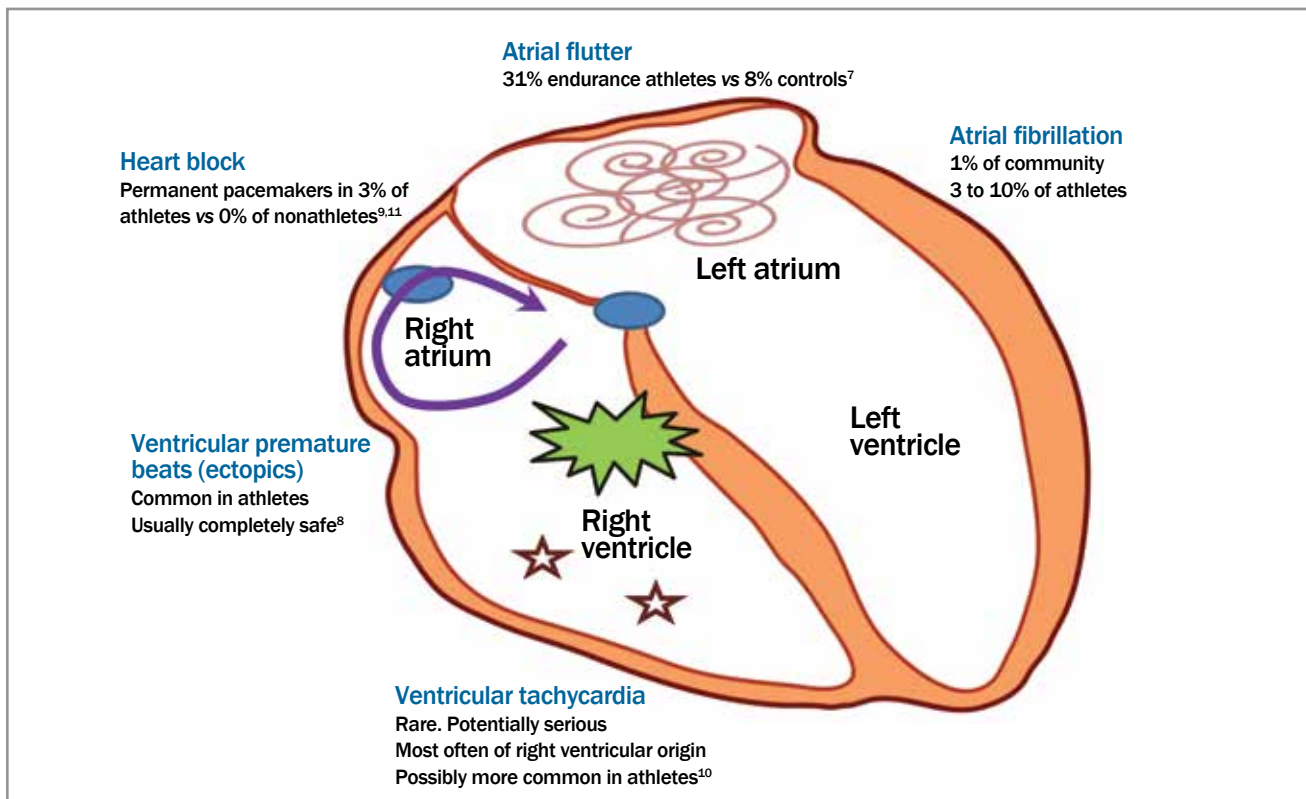


Figure 4. Increased incidence of arrhythmias in the athlete's heart. There is an increase in atrial fibrillation/flutter in athletes.<sup>2,6,7</sup> There is also an increase in premature ventricular beats,<sup>8</sup> although this tends to be benign in the vast majority of athletes. Although there is some speculation that extreme exercise may cause serious arrhythmias in some cases,<sup>9,11</sup> these events remain very rare.

intense exercise training also increases the risk of serious arrhythmias such as ventricular tachycardia. Some groups have reported clusters of endurance athletes (professional cyclists) who have developed potentially life-threatening ventricular arrhythmias.<sup>9,10</sup> However, there is no good epidemiological evidence to prove that these cases are more common in athletes than nonathletes.

The treatment and management of the athlete presenting with palpitations, syncope or arrhythmias can be extremely challenging. Decision-making depends on specific ECG features in combination with cardiac imaging. In some cases, advanced imaging techniques, such as MRI, invasive electrophysiological studies or, very rarely, cardiac biopsy are required. Referral of the patient to a specialist centre should be encouraged recognising that, although rare, even the fittest athletes can develop serious cardiac rhythm problems.

## Conclusion

Exercise provides wide ranging health benefits including improved cardiovascular health and yet, paradoxically, there is mounting evidence to suggest that extreme intense exercise may increase the risk of some arrhythmias. Although there is a need for greater understanding of the effects of endurance exercise on the heart, this should not detract from the promotion of the unequivocal benefits of exercise in the vast majority.

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