Review Article

New Perspectives in The Assessments of Left Atrial Function in Athletes

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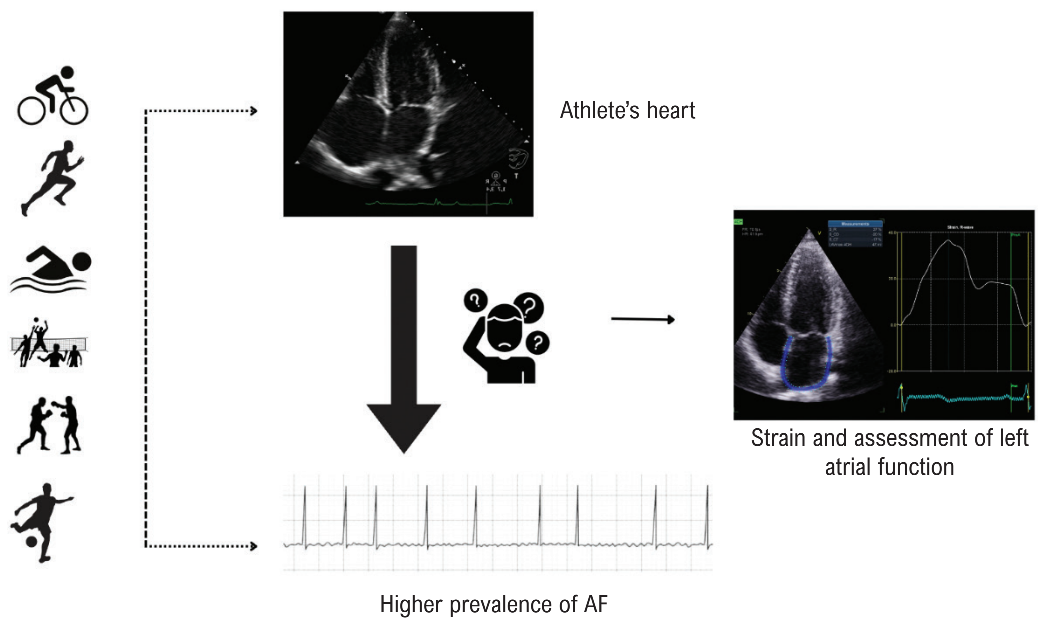
Central Illustration: New Perspectives in The Assessments of Left Atrial Function in Athletes



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Assessment of atrial function in athletes. Searching for new ways to help differentiate between physiological adaptations and pathological remodeling.

Abstract

In high-performance athletes, especially those who practice endurance sports that involve high-intensity training for long periods, the heart shows electrical, functional, and structural changes, increasing the likelihood of ventricular and atrial arrhythmias. It is already known that these athletes have increased left atrium (LA) diameter and indexed volume. However, the effects of these changes on atrial function are not yet fully understood. The mechanics of the LA involve three functions: 1) it acts as a reservoir that collects venous flow from the pulmonary veins, occurring during ventricular systole; 2) it acts as a conduit, allowing the passive filling of the left ventricle; and 3) it acts as a contractile pump, expressed by atrial contraction. Recently, the analysis of atrial function through myocardial deformation using the speckle tracking technique has been increasingly used and contributed to the understanding of atrial mechanics. Endurance athletes have greater atrial adaptations, including greater LA diameter and volume, probably caused by the repetitive and sustained increase in effort preload to meet the cardiac output demand during high-intensity training. In addition to an increased LA, studies have shown a reduced reservoir function in athletes when compared to the control group. Therefore, we believe these findings may contribute to a more effective stratification

Keywords

Atrial Function; Athletes; Echocardiography

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of patients at higher risk of developing atrial fibrillation (AF). Finally, we understand that further studies are needed to better understand the dose-response relationship between exercise and left atrial function.

Left Atrial Function and Physical Exercise

The benefits of physical exercise are clear, with several studies demonstrating that individuals who are more active and have greater functional capacity have fewer negative cardiovascular outcomes and lower mortality, regardless of other risk factors.[1-3] However, it is well documented in the literature that athletes exposed to high-intensity training at high frequencies are susceptible to potentially detrimental cardiac adaptations, including atrial fibrillation (AF), coronary calcification, myocardial fibrosis, and left atrial dilation.[4-8]

In high-performance athletes, especially those who practice endurance sports that involve high-intensity training for long periods, the heart undergoes profound electrical, functional, and structural changes, which increases the likelihood of ventricular and atrial arrhythmias.[9] The need to increase cardiac output during exercise leads to biatrial dilation, left ventricular (LV) hypertrophy, and increased LV diameter and systolic volume.[8] The presence and degree of these adaptations may vary according to the type of exercise practiced, volume, and intensity of training, in addition to individual susceptibility, such as age, gender, and genetic predisposition.[10]

It is already known that high-performance athletes have increased LA diameter and indexed volume, especially those who practice endurance sports.[7] LA dilation is correlated with an increase in cardiovascular events, even in patients who do not have valve disease or AF.[11] However, the effects of atrial function remodeling caused by sport are not yet fully understood (Central Illustration).

Although it is a consensus that high-performance athletes have a larger left atrium (LA) with larger volume and dimensions, we still have much to understand about atrial function and its adaptations in athletes with different levels of training.[7] For a long time, the studies aimed to assess the adaptations found in the LV; nevertheless, in recent years, there has been growing interest in understanding the atrial adaptations caused by sport since the atrium plays an important role in ventricular filling and, consequently, in increasing cardiac output during exercise. Ways to assess left atrial function are needed to help differentiate between physiological adaptations to exercise and pathological remodeling.

The mechanics of the LA involve three functions: 1) it acts as a reservoir that collects venous flow from the pulmonary veins, occurring during ventricular systole; 2) it acts as a conduit, allowing the passive filling of the LV; and 3) it acts as a contractile pump, expressed by atrial contraction.[12] Each of these phases can be assessed in different ways, including LA volumetric assessment, Doppler echocardiography with transmitral and pulmonary flow velocities, left atrial ejection fraction and kinetic energy, LA tissue Doppler, and strain rate.[12]

Recently, the analysis of atrial function through myocardial deformation using the speckle tracking technique known as left atrial strain (LAS) has been increasingly used and contributed to the understanding of atrial mechanics. One of the advantages of this technique is that it is less operator-dependent since it is not necessary to perfectly align the ultrasound beams. In this method, the reflections of ultrasonic waves in different types of tissue produce pixels in different shades of gray according to the amplitude of the reflected wave, generating natural acoustic markers known as speckles. Myocardial deformation can be calculated by tracking and moving these markers.[13]

The quantification of longitudinal strain can assess LA function throughout the cardiac cycle and, consequently, during all phases of atrial mechanics.[14] LAS in the reservoir phase (LASr) assesses function in the rapid filling phase, LAS in the conduit phase (LAScd) assesses function in the passive emptying phase, and LAS in the contraction phase (LASct) assesses function in the active emptying phase. By assessing atrial function, LV diastolic function can be indirectly analyzed, which is extremely relevant for athletes since atrial enlargement alone does not characterize diastolic dysfunction, with other parameters being necessary to aid in the differential diagnosis.[15,16] For LAS analysis, LA 4-chamber and 2-chamber apical views are essential, optimized and with a high frame rate, usually between 40 and 80 fps. A specific cardiac cycle is selected, and the point-by-point tracing is manually drawn from the endocardial border of the mitral annulus to the opposite mitral annulus, extrapolating the entry of the pulmonary veins and the left atrial appendage. The software defines the myocardial region of interest, which is adjusted to 3 mm in width and must cover from the endocardial to the epicardial border. If the tracking quality is not approved in two or more segments, even after manual adjustment, this incidence must be excluded from the analysis. Finally, the software calculates the strain for each of the apical windows mentioned above.[15]

In the LAS analysis, two different methods can be used to assess function: the first one uses the QRS complex as a reference point, and it measures the positive peak of the atrial longitudinal strain (equivalent to the reservoir function) and the strain at the time of atrial contraction (represented in the electrocardiogram by the P wave). The second method uses the P wave as a reference and, initially, obtains a negative peak (equivalent to the contraction function) and, subsequently, a positive peak (equivalent to the conduit function).[17] Highly heterogeneous LAS normal values can be found in the literature. The best evidence we currently have is based on the 2017 meta-analysis and consists of 39%, 23%, and 17% for LASr, LAScd, and LASct, respectively.[18]

As with other cardiological adaptations seen in athletes, the magnitude of the changes in the atrium depends mainly on age, type of sport practiced, intensity, and training duration. Regarding age, master athletes have associated changes to LA function closely linked to LV diastolic properties, regardless of the sport practiced.[19] Recent studies have shown that atrial volume is correlated with the number of hours of training throughout life, with athletes with more than 3,600 hours of training having a higher risk of left atrial dilation.[20]

In elite basketball athletes, in addition to increased LA volume, a reduction in the reservoir function and conduit tension was observed, with no difference in LA reinforcement tension.[21] An increase in LA volume and a tendency towards a reduction in the reservoir function (37 x 39.4%) were also evidenced in an important meta-analysis[22] published in 2019, as well as a reduction in the contractile function (12.4 x 17.4%) when comparing elite athletes with the normal population. Another article that evaluated elite handball athletes identified an increase in the volume of the right and left atria, as well as a reduction in myocardial deformation during atrial systole when comparing the group of athletes with the control group.[23] These findings corroborate the results found in a prospective study in which elite female volleyball athletes trained intensively 16 hours/week for 16 weeks. In the post-training evaluation, an increase in the biatrial indexed volume was observed, as well as a significant reduction in the reservoir function and atrial contraction.[24] An observational study in 1,073 university athletes showed increased LA in 19.1% and alteration in the reservoir function in 5.2% of the population studied, showing that athletes with atrial enlargement had a higher prevalence of reduced reservoir function.[25]

Improved atrial function in this population is probably due to greater ventricular compliance. However, it is known that patients who train intensively can undergo changes, such as greater myocardial fibrosis, which can compromise ventricular compliance and supposedly lead to worse atrial function in this population, reinforcing the "reverse J" behavior found in other cardiac adaptations. This behavior is even shown to be present in the correlation between cardiovascular risk and training load (Figure 1).[5] Nevertheless, this hypothesis was not fully tested in previous studies, as athletes were compared with a control group and were not stratified by performance levels or training time.

The correlation between exercise dose (intensity x volume) and the prevalence of AF has also followed a "J" pattern, i.e., the practice of exercise between 5 and 20 MET-h/week has a protective effect against AF. In contrast, the practice of exercise with an intensity greater than 55 MET-h/week tends to involve a higher incidence of AF.[4] The higher prevalence of AF at higher training intensity and volume is suggested to be correlated with expected atrial adaptations in athletes. Athletes with increased left atrial volume and reduced atrial emptying have a higher prevalence of AF, even with normal LV diastolic parameters, demonstrating different pathophysiology from non-athlete individuals, who have a high correlation with diastolic dysfunction. This suggests that the increased prevalence of AF in athletes may be associated with atrial myopathy resulting from atrial stretching triggered by physical training.[26] Therefore, it is extremely important to be aware of the potential adaptations found at different levels of performance to better understand atrial adaptations among athletes and the correlation involving the increased incidence of AF in this population.

Author Contributions

Conception and design of the research: Almeida RL, Santos AC; writing of the manuscript: Almeida RL, Brasileiro-Santos MS, Lima IAB, Santos EP, Moura SKMSF, Santos AC; critical revision of the manuscript for intellectual content: Almeida RL, Brasileiro-Santos MS, Lima IAB, Santos EP, Moura SKMSF, Tavares M, Santos AC.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

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Ethics Approval and Consent to Participate

This article does not contain any studies with human participants or animals performed by any of the authors.

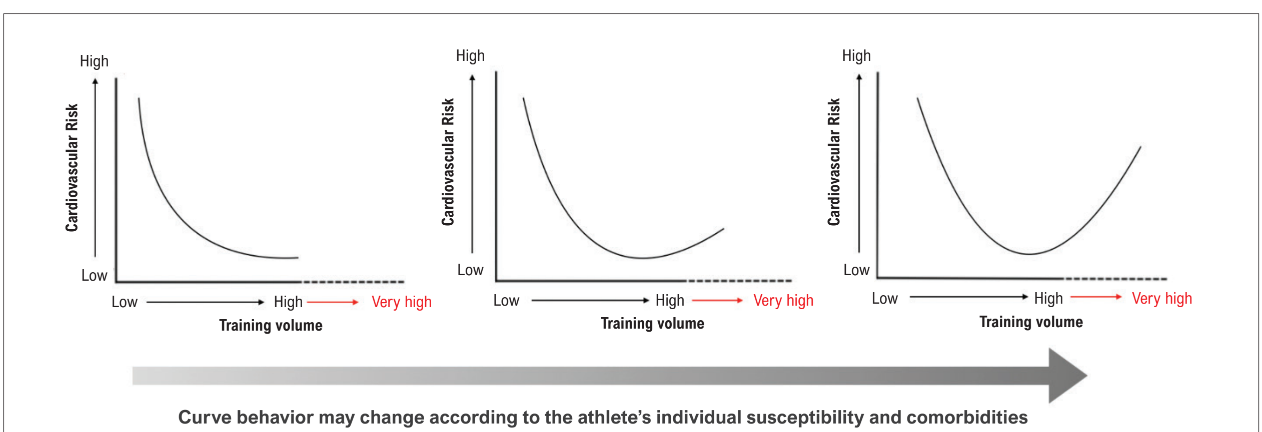

Figure 1 – *Dose-response association between physical training volume and cardiovascular health outcomes. Adapted from Franklin et al.[5]*

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