

Mechanical diversity in the adaptation of left and right ventricular function to long-term exercise: 3D echocardiographic study in a large cohort of competitive athletes

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Regular physical exercise results in complex remodelling of the left- (LV) and right ventricle (RV), commonly referred as the athlete's heart. Despite the well-known changes in ventricular volumes and mass, data are scarce regarding ventricular mechanics and its connection to exercise performance.

Accordingly, our aim was to characterize biventricular morphological and functional changes and their association with peak exercise capacity in a large cohort of athletes using three-dimensional (3D) echocardiography.

Competitive athletes of various training regimes (n=525, age: 20±6 years, training: 15±7 hours/week, 30% female) were enrolled, while 73 age- and gender-matched sedentary volunteers served as the control group. Full volume 3D echocardiographic datasets focused on the LV or the RV were acquired for further analysis: LV and RV end-diastolic volume (EDVi), LV mass (Mi) indices and ejection fraction (EF) were quantified. To characterize biventricular mechanics, LV and RV global longitudinal strain (GLS) and global circumferential strain (GCS) were also measured using dedicated software. Athletes also underwent cardiopulmonary exercise testing to determine peak oxygen uptake (VO₂/kg).

Athletes had significantly higher LV and RV EDVi (81±13 vs. 64±11 mL/m²; 83±14 vs. 63±11 mL/m²; both p<0.001) and also LVMI (87±15 vs. 65±12

g/m²; p<0.001) compared to controls. LV and RV EF were significantly lower in athletes (57±5 vs. 60±6%; 55±5 vs. 58±5%; both p<0.001). LV GLS (−19.5±2.1 vs. −20.6±2.6%; p<0.001) and also LV GCS (−27.9±3.2 vs. −29.8±4.4%; p<0.001) was lower in athletes compared to controls. In opposed to the LV, RV GLS did not differ between the two groups (−29.3±5.8 vs. −29.5±5.3%; p=NS), however, RVGCS was decreased in athletes compared to controls (−24.4±6.1 vs. −28.6±7.3%; p<0.001). In athletes, ventricular morphology measured by LV and RV EDVi correlated with VO₂/kg (both r=0.37; p<0.001), while functional measures, such as lower resting LV GLS (r=0.22; p<0.001) and RV GCS (r=0.14; p<0.01) also showed relationship with better exercise performance.

According to our results, regular physical exercise is associated with significant changes of LV and RV geometry and mechanics. Resting biventricular systolic function of the athlete's heart is characterized by a mild reduction, which is attributable to a lower longitudinal and circumferential shortening on the left side of the heart, while on the right side lower circumferential shortening can be seen along with a maintained longitudinal shortening. Moreover, this mechanical pattern also correlates with exercise performance.