specific METS is highlighted in Table 1. In summary, low-intensity exercise is defined as corresponding to 1.8–2.9 METS, moderate intensity is defined as 3–6 METS and high-intensity exercise as > 6 METS [28].

The magnitude of adaptation is greatest in those athletes who engage in predominantly mixed (combined dynamic and strength) or endurance exercise rather than pure resistance training [29–31]. Endurance/ dynamic activity can be defined as aerobic isotonic dynamic exercise at incremental workloads of 70–90% of maximum heart rate and includes sporting disciplines such as long- and middle-distance running, swimming or cycling as well as common team sports such as soccer and basketball. Resistance training can be defined as anaerobic dynamic exercise at incremental workloads of > 30% maximal voluntary contraction and includes sporting disciplines such as martial arts, sumo wrestling, shot-put and weightlifting. It is important to note that many sporting disciplines and training regimes involve a combination of resistance and endurance exercise (for example, boxing, rugby, rowing, and American football).

Studies using echocardiography have highlighted the specific type of left ventricular (LV) structural adaptation in athletes and have usually highlighted normal geometry or eccentric hypertrophy i.e. LV cavity enlargement with concomitant increase in LV wall thickness [32]. Left ventricular concentric hypertrophy is rare in all types of training (3–12% and 0–8% in male and female athletes respectively [32, 33]) and although it has been documented more frequently in athletes of black ethnicity and those who are older with a lifelong exposure to exercise [32–34] there is little evidence to support previous theories of it being a primary response to resistance training [27, 35]. Most studies highlight the multifactorial nature of the athlete's heart with additional factors such as body size [32] also impacting the magnitude of structural adaptation [26]. In view of this, scaling to body size is mandated in athletes. Although the ideal approach is to scale allometrically, there is currently a lack of sufficient population-based exponents and the associated normal athletic ranges to make this approach clinically useful and hence a standard ratiometric / linear scaling to body surface area (BSA) or height is currently recommended.

Table 1 Sporting examples demonstrating specific MET values for determining exercise Intensity (adapted from Hermann et al. 2023)

Sporting discipline	Metabolic equivalent (MET)
Soccer	9.5
Running (6 mph)	9.3
Running (7.5 mph)	11.0
Running (8 mph)	12.0
Cycling (Racing > 20 mph)	16.8
Cycling (Leisure < 10 mph)	5.8
Cricket	4.8
Rugby	8.3
Tennis (singles)	8.0
Field Hockey	7.8
Netball	7.0
Boxing	12.3
Golf	4.5
Rowing (competitive)	15.5
Swimming (leisure)	6.0
Swimming (competitive)	10.5
Weight lifting	6.0

Structural adaptation of the right ventricle (RV) occurs in athletes of predominantly mixed / endurance exercise training [36, 37] with balanced adaptation of the inflow and outflow [38]. These adaptations occur irrespective of body size [39] and ethnicity [40]. Right ventricular adaptation [40, 41] is also proportional to LV enlargement and hence an objective and subjective assessment of the relative adaptation can provide valuable insight [42]. The atria of the heart are no exception to physiological enlargement with the greatest magnitude of adaptation seen in athletes of high dynamic sports [43], balanced to both right and left atria and across athlete demographics [44, 45]. Although absolute values of all chambers are greater in males, female athletes also demonstrate proportional adaptation highlighting the independent impact of a training stimulus.

The echocardiographic assessment of LV and RV function (systolic and diastolic) is important to aid differentiation from inherited cardiomyopathies and hence a thorough understanding of functional adaptation to exercise training is vital [26]. Generally, systolic functional indices, ejection fraction (EF), global longitudinal strain (GLS), RV free wall strain (RVFWS) RV fractional area change (RVFAC) and tissue Doppler indices are within the published normal ranges for non-athletes [26]. However, it is important to note that 12–17% of predominantly male athletes may have borderline-low or reduced resting values of EF, GLS and RVFAC [20, 46–49]. The mechanism is thought to be related to the physiologically enlarged chambers requiring a lower contractile state to deliver a sufficient stroke volume (SV) at rest alongside a low resting heart rate (HR) [50] secondary to high vagal tone. It is important to note that these physiological functional changes are related to structural adaptation and hence it is less common to observe low resting functional indices from normal-sized chambers such as in resistance trained athletes [27, 51, 52] There are a small