Progress in Cardiovascular Diseases 54 (2012) 387–396
www.onlinepcd.com

# Assessment of Left Ventricular Hypertrophy in a Trained Athlete: Differential Diagnosis of Physiologic Athlete's Heart From Pathologic Hypertrophy

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**Abstract** Physiologic LV remodeling in young trained athletes as a consequence of chronic training can occasionally mimic certain pathologic conditions associated with sudden death, such as HCM. A small but important subset ofelite male athletes may show a borderline increased LV wall thickness of 13 to 15 mm, which defines a gray zone of overlap between the extreme expressions of athlete's heart and a mild HCM phenotype. Such diagnostic ambiguity can be resolved by using the paradigm of noninvasive parameters including testing with echocardiography (and, more recently, with CMR): left atrial and LV chamber dimensions and shape, brief periods of deconditioning to alter LV mass, measurement of oxygen consumption and diastolic filling, and recognition of familial occurrence of HCM or a pathogenic HCM-causing sarcomere mutation. Such distinctions between physiologic/benign athlete's heart and HCM, the most common cause of sudden death in the young in the United States, can be crucial. The recognition of HCM leads to disqualification from intense competitive sports to reduce sudden death risk and, when appropriate, permits initiation of therapeutic interventions. (Prog Cardiovasc Dis 2012;54:387-396)


*Keywords:* Left ventricular hypertrophy; Trained athlete; Pathologic hypertrophy

## Historical perspectives

The concept that the cardiovascular system of trained athletes differs structurally and functionally from that of untrained, normal individuals is remarkably more than 100 years old.[1] Henschen[1] is credited with the first description in 1899, using only a basic physical examination with careful percussion to recognize enlargement of the heart due to athletic activity in cross-country skiers. Henschen[1] concluded that both dilatation and hypertrophy were present in trained athletes, involving the left and right sides of the heart and that these changes were normal and favorable: "skiing causes an enlargement of the heart which can perform more work than a normal heart."

In the mid-20th century, investigators used quantitative chest radiography to demonstrate that heart size was increased in athletes, particularly in those engaged in endurance sports with large aerobic capacity. Some observers regarded the heart of the trained athlete to be weakened because of the "strain" created by continuous and strenuous training, subject to deteriorating cardiac function and possible heart failure.[2] From that time, there has been periodic controversy regarding the intrinsic nature of an athlete's heart—that is, whether the morphologic alterations evident are benign physiologic adaptations and the consequence of the training or,

Statement of Conflict of Interest: see page 395.

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doi:10.1016/j.pcad.2012.01.003

**Abbreviations and Acronyms**

**AGT** = angiotensin

**CMR** = cardiovascular magnetic resonance

**HCM** = hypertrophic cardiomyopathy

**LGE** = late gadolinium enhancement

**LV** = left ventricle

**TDI** = tissue Doppler imaging

alternatively, are potentially pathologic and the harbinger of disease and future disability.

In the last 2 decades, imaging techniques have allowed direct assessment of the morphologic and functional cardiac changes induced by athletic conditioning, and several investigations, largely based on the long-standing cardiovascular program of the Institute of Sport Medicine and Science in Rome, have provided extensive information in a variety of athlete populations including elite competitors.[3-11]

## Determinants of cardiac remodeling

### *Type of sport*

Morphologic cardiac changes in athletes have been attributed primarily to the type of sport and, specifically, to the hemodynamic overload induced by various conditioning programs[3-9] (Fig 1). Specifically, endurance sports (ie, cycling, cross-country skiing, and rowing) are associated with a predominant volume overload, whereas power disciplines (ie, weight and power lifting, shot put, and discus) are associated with a predominant pressure overload. In our experience, elite athletes engaged in endurance sports demonstrate the greatest alterations in left ventricular (LV) cavity size, wall thickness, and mass.[5,9] Athletes engaged in power disciplines show a disproportionately larger impact on LV wall thickness than cavity size; whereas LV cavity dimensions remain within normal limits; the relative wall thickness is increased. Other disciplines such as soccer, rugby, hockey, those involving mixed (aerobic and anaerobic) exercise programs show a moderate impact on LV cavity size, with absolute dimensions that commonly exceed the normal limits; however, LV wall thicknesses usually remain within normal limits.[9,10] Finally, skill and technical disciplines (such as golfing, equestrian, or yachting) have only a minimal remodeling effect, if any, on cardiac morphology.[9]

### *Body size and composition*

Cardiac dimensions are closely related to body size and composition. Body surface area has proven to be the strongest determinant of cardiac dimensions.[5,9] Indeed, athletes with the greatest body surface area (and largest lean body mass), such as those engaged in rowing, rugby, basketball, and water polo, usually have the greatest absolute LV cavity dimensions.[4,5]

### *Sex*

Women athletes have larger LV cavity dimension (average, +6%) and maximal wall thickness (average, +14%) compared with sedentary female controls.[11] However, the extent of LV remodeling in absolute terms is usually mild in trained women athletes, and specifically, LV wall thickness do not exceed the upper normal limits (ie, 12 mm) and do not usually fall into a “gray zone” of borderline LV hypertrophy.[11] Not unexpectedly, women athletes show smaller absolute LV cavity dimensions (average, −10%) and wall thicknesses (average, −20%) in comparison with male athletes of the same age, ethnic origin, and sporting disciplines.[11] These differences are likely the consequence of several determinants including the smaller body size (and lean body mass) and the lower absolute cardiac output and systolic

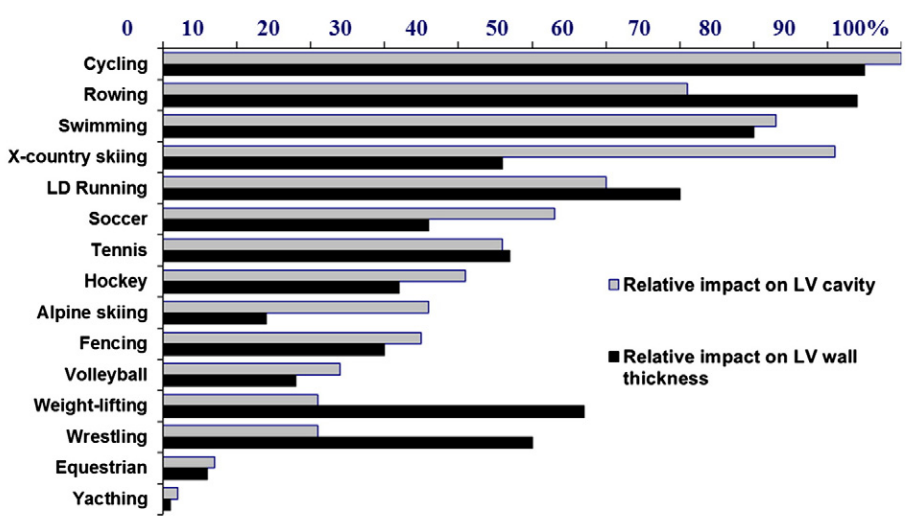


Fig 1. Effect of specific sports training on either LV cavity dimension or wall thickness in elite athletes representing different types of sport disciplines.