

THE PRESENT AND FUTURE

STATE-OF-THE-ART REVIEW

Sports Cardiology

Core Curriculum for Providing Cardiovascular Care to Competitive Athletes and Highly Active People



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ABSTRACT

The last few decades have seen substantial growth in the populations of competitive athletes and highly active people (CAHAP). Although vigorous physical exercise is an effective way to reduce the risk of cardiovascular (CV) disease, CAHAP remain susceptible to inherited and acquired CV disease, and may be most at risk for adverse CV outcomes during intense physical activity. Traditionally, multidisciplinary teams comprising athletic trainers, physical therapists, primary care sports medicine physicians, and orthopedic surgeons have provided clinical care for CAHAP. However, there is increasing recognition that a care team including qualified CV specialists optimizes care delivery for CAHAP. In recognition of the increasing demand for CV specialists competent in the care of CAHAP, the American College of Cardiology has recently established a Sports and Exercise Council. An important primary objective of this council is to define the essential skills necessary to practice effective sports cardiology. (J Am Coll Cardiol 2017;70:1902-18)
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Competitive athletes and highly active people (CAHAP) are a growing population. Although routine physical exercise is an effective way to reduce the risk of cardiovascular (CV) disease, it does not confer complete immunity (1,2), and actually increases the risk of CV events acutely, even in trained individuals (3). The complex interplay between CV disease and vigorous physical activity remains incompletely understood, but is increasingly

relevant in clinical practice. People with occult CV disease are susceptible to sudden cardiac death during exercise. However, sudden death prevention represents only 1 element of caring for CAHAP. Accurate interpretation of diagnostic testing with an emphasis on differentiating pathology from physiological exercise-induced adaptation, efficient and targeted assessment of symptoms, and provision of longitudinal care including the development of exercise



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recommendations following CV disease diagnosis are all critical skills for the effective clinical care of CAHAP.

Multidisciplinary teams comprising athletic trainers, physical therapists, primary care sports medicine physicians, and orthopedic surgeons have traditionally provided clinical care for CAHAP, and this team-based approach will continue to represent the standard of care. However, the optimal CAHAP care team includes a dedicated CV specialist to provide collaboration during pre-participation cardiovascular disease screening (PPCS), evaluation and management of athletes with suspected and confirmed CV disease, and participation in the generation of policies designed to maximize safe sport participation. The practice of sports cardiology is growing at a rapid pace, yet currently, an official competency statement such as those developed by the Core Cardiovascular Training Statement and endorsed by the American Board of Internal Medicine for other CV subspecialties is lacking. This document was written in response to this unfulfilled need. The purpose of this paper is to highlight the basic fund of knowledge and the corollary skills required for the effective practice of sports cardiology. Although the present document was not designed to serve as a formal education curriculum or template for continuing medical education, it is anticipated that it will set the stage for future discussions about how to include sports cardiology into existing CV training requirements and board certification processes. This document identifies 4 fundamental clinical domains of knowledge that are critical to the care of CAHAP (**Central Illustration**). Each domain will be defined, and key skill sets and/or clinical approach algorithms will be presented. Recommendations in this document are based on available evidence, and where evidence is lacking, reflect expert opinion. Recommendations are presented in a *Medical Knowledge* and *Patient Care and Procedural Skills* format to maintain consistency with the American College of Cardiology's (ACC's) recent Lifelong Learning statement (4). It is anticipated that this document will provide a clinical framework for CV practitioners who participate in the care of CAHAP.

EXERCISE-INDUCED CARDIAC REMODELING VERSUS CV PATHOLOGY

Moderate- to high-intensity physical activity, either for recreational exercise or competitive athletics, requires an adaptive and healthy CV system. The CV system adapts to repetitive bouts of exercise through a complex series of structural and functional changes.

These adaptations often manifest during clinical evaluation and may be evident during physical examination and interpretation of diagnostic testing. Accurate interpretation of clinical data derived during the assessment of CAHAP requires an understanding both of basic exercise physiology and the numerous adaptive CV changes that are common in this patient population. Essential knowledge base and skill sets for the sports cardiologist pertaining to exercise physiology and exercise-induced cardiac remodeling (EICR) are shown in **Table 1**.

FUNDAMENTAL CLINICAL EXERCISE

PHYSIOLOGY. All forms of vigorous physical activity and competitive athletics involve some combination of static and dynamic exercise physiology (5). The terms *static* and *dynamic* refer to patterns of skeletal muscle activity and their consequent changes in CV structure and function. Static activity is characterized by short and forceful skeletal muscle contractions, which can be quantified as an estimated percentage of maximal voluntary contraction for involved muscle groups. During bouts of relatively pure static/strength activities, such as power weight lifting and track and field throwing events, intense skeletal muscle activation coupled with stimulation of mechanical and metabolic afferent signals lead to acute increases in systemic vascular resistance and arterial blood pressure. The primary role of the CV system during acute bouts of static activity is to *maintain* cardiac output in the face of increased left ventricular (LV) afterload. This is accomplished by increasing myocardial contractility, which facilitates preservation of end-diastolic and -systolic LV volume. In contrast, dynamic/endurance activities are characterized by repetitive, often rhythmic contraction and relaxation of large skeletal muscle groups, which require increases in oxidative metabolism. The intensity of dynamic activity can thus be quantified by measurement of oxygen uptake ($\dot{V}O_2$). The primary CV response to dynamic activity is to *increase* cardiac output to ensure adequate delivery of metabolic substrate to active muscle beds. The magnitude of cardiac output augmentation is tightly regulated by energetic signals in skeletal muscle, is proportional to the intensity of the dynamic activity, and is accomplished by increases in heart rate, augmentation of stroke volume, and reductions in systemic vascular resistance. Diseases of the CV system that impair the ability to maintain cardiac output in the face of increased LV afterload and/or to increase cardiac

ABBREVIATIONS AND ACRONYMS

- ACC** = American College of Cardiology
- AHA** = American Heart Association
- ASCVD** = atherosclerotic cardiovascular disease
- CAHAP** = competitive athletes and highly active people
- CV** = cardiovascular
- ECG** = 12-lead electrocardiography
- EICR** = exercise-induced cardiac remodeling
- ICD** = implantable cardiac defibrillator
- LV** = left ventricular
- PPCS** = pre-participation cardiovascular disease screening
- RV** = right ventricular

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