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AHA/ACC SCIENTIFIC STATEMENT

Eligibility and Disqualification Recommendations for Competitive Athletes With Cardiovascular Abnormalities: Task Force 1: Classification of Sports: Dynamic, Static, and Impact

A Scientific Statement From the American Heart Association and American College of Cardiology

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The "classification of sports" section has been a part of each iteration of the recommendations for participation in sports and provides a framework by which athletes with heart disease can be prescribed or proscribed specific sports for participation (1-3). For the 36th Bethesda Conference, an earlier version of the **Figure** was constructed that characterized sports by their strength component, expressed as the relative intensity of static muscle contractions (percentage of a maximal voluntary contraction), and their endurance component, reflected by the relative intensity of dynamic exercise (regular contraction of large muscle groups) or percentage of maximal aerobic power ($\dot{V}O_{2max}$) (3). The rationale for a classification scheme applicable to the competitive athlete with cardiac disease is based on the well-described hemodynamics of each different type of exercise (static versus dynamic) (3,4), as well as the apparent cardiac adaptation of athletes who compete in these sports (5), which reflects the chronic load on the

*On behalf of the American Heart Association Electrocardiography and Arrhythmias Committee of the Council on Clinical Cardiology, Council on Cardiovascular Disease in the Young, Council on Cardiovascular and Stroke Nursing, Council on Functional Genomics and Translational Biology, and the American College of Cardiology.

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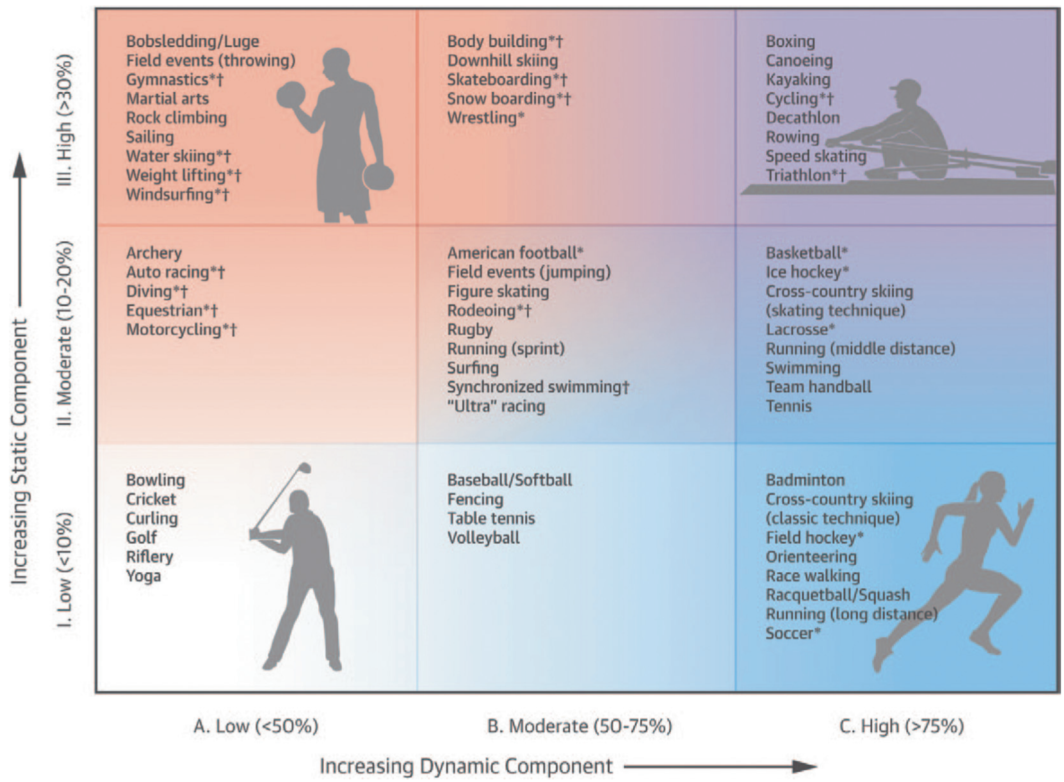
FIGURE **Classification of Sports**



This classification is based on peak static and dynamic components achieved during competition; however, higher values may be reached during training. The increasing dynamic component is defined in terms of the estimated percentage of maximal oxygen uptake ($\dot{V}O_{2max}$) achieved and results in an increasing cardiac output. The increasing static component is related to the estimated percentage of maximal voluntary contraction reached and results in an increasing blood pressure load. The lowest total cardiovascular demands (cardiac output and blood pressure) are shown in the palest color, with increasing dynamic load depicted by increasing blue intensity and increasing static load by increasing red intensity. Note the graded transition between categories, which should be individualized on the basis of player position and style of play. *Danger of bodily collision (see **Table** for more detail on collision risk). †Increased risk if syncope occurs. Modified from Mitchell et al. (3) with permission. Copyright © 2005, *Journal of the American College of Cardiology*.

cardiovascular system. The underlying principle is that specific cardiovascular conditions may be more or less susceptible to complications (primarily ischemia, heart failure, or vascular compromise) based on unique characteristics of each lesion and the load placed on the heart during athletic competition.

Static contractions stimulate mechanical and metabolic afferents in skeletal muscle, which leads to large, sustained changes in blood pressure via the exercise pressor reflex (6–8). The larger the muscle mass involved, the greater the intensity of contraction, and the greater the rise in blood pressure (9); incorporation of a Valsalva maneuver during contractions will acutely and transiently increase transmural arterial pressure markedly in blood vessels outside of the chest, although left ventricular (LV) afterload does not appear to increase (10) because of a balanced rise in intracardiac and intrathoracic pressure inside the chest. Dynamic exercise increases the demand for blood flow and cardiac output in proportion to the metabolic demand ($\dot{V}O_2$): for every 1 L/min increase in oxygen uptake, there is an obligate requirement for a 5 to 6 L/min increase in cardiac output (4,11) as a function of the Fick equation. This increase is independent of age, sex, or fitness (4,12,13).

Both dynamic and static exercise result in an increase in myocardial oxygen demand: heart rate, wall tension (before and after the contraction, which determines preload and afterload), and contractile state of the LV (14). During high-intensity dynamic exercise, there is a large increase in heart rate and an increase in stroke volume that is achieved by both an increase in end-diastolic volume (Frank-Starling mechanism) (15) and a decrease in end-systolic volume (increased contractile state); for athletes, the most important factor is the increase in end-diastolic volume (16). In high-intensity static exercise, a smaller increase occurs in heart rate, and little change occurs in end-diastolic and end-systolic volumes of the LV; however, arterial pressure and contractile state of the ventricle are increased. Thus, dynamic exercise primarily causes a volume load on the LV, whereas static exercise causes a pressure load. Virtually all sports require a combination of both types of effort, although when both are high, such as in rowing sports, the rise in blood pressure may be dramatic (17), and the cardiac adaptation is among the most prominent of all sports (18).

CLASSIFICATION OF SPORTS

On the basis of these considerations, the following matrix was developed (**Figure**). This **Figure** has been modified only slightly from the initial derivation published in the 36th Bethesda Conference, mostly to emphasize a more graded increase in effort/cardiovascular load between categories as opposed to a hard, discrete distinction.

Each sport is categorized by the level of intensity (low, medium, high) of dynamic or static exercise generally required to perform that sport during competition. It also recognizes those sports that pose a significant risk because of bodily collision, either because of the probability of hard impact between competitors or between a competitor and an object, projectile, or the ground, as well as the degree of risk to the athlete or others if a sudden syncopal event occurs. Thus, in terms of their dynamic and static demands, sports can be classified as IIIC (high static, high dynamic), IIB (moderate static, moderate dynamic), IA (low static, low dynamic), and so forth. For example, an athlete with a cardiovascular abnormality that would preclude a sport that produces a high pressure load on the LV may be advised to avoid sports classified as IIIA, IIIB, and IIIC. It should be emphasized that in terms of the classification of sports matrix presented in the **Figure**, cardiovascular abnormalities designated as compatible with a high level of intensity in any particular category also (by definition) permit participation in levels of lesser intensity. For example, if class IC sports are appropriate (low static/high dynamic), then so are classes IA and IB (low static/low and moderate dynamic). Sports in each category are listed in alphabetical order to make them easier to find.

Although this scheme has been very useful in guiding practitioners and allowing recommendations for sports participation, there are a number of key limitations that must be acknowledged to use this approach to guide recommendations for individual athletes:

- The scheme as described is simplistic and is only a rough guide. It must be acknowledged that within each sport, different position players may have quite different cardiovascular loads, for example, wide receiver or offensive lineman in American football, goalie versus midfielders or forwards in soccer, 50 m versus 400 m distances in swimming, and short-track versus long track speed skating. This differential load may even be manifest at the lowest-intensity sports such as yoga, which also can be practiced at much higher intensities. Therefore, practitioners should be prepared to individualize the classification scheme based on individual athletes and how they play their specific sport and position.
- Even within individual sports, the cardiovascular load may be quite different at different times during the competition. As such, it is recommended that the highest level achieved during competition be used for exercise prescription, even if this level is achieved relatively infrequently.
- The types and intensities of exercise required for training may be different from those achieved during a competition. Therefore, cardiovascular loads experienced during training, including high-intensity interval efforts, and during a game must be considered.
- These guidelines are intended for competitive sports and their required training regimen but may not apply to participation in sports at a recreational level. Moreover, many higher-class activities (such as cycling and running) can be performed by patients with cardiovascular disease after they have received counseling about intensity restriction and competition avoidance as part of healthy secondary prevention.
- Environmental conditions may alter the cardiovascular load for a given sport substantially. Increasing altitude alters oxygen availability and acutely increases the heart rate and cardiac output for any given absolute work rate (19). In patients with underlying coronary heart disease, it may also reduce the myocardial workload required to cause ischemia (20) and increase the risk of sudden death (21), although even short-term acclimatization appears to reduce this risk significantly (21). Heat is also a substantial stressor; because humans thermoregulate by sending blood to the skin, a large extra amount of cardiac output is required to maintain body temperature (22), and this could increase the dynamic classification of some sports (especially "hot yoga"). For patients with limited capability to augment cardiac output, thermal stress may be particularly problematic (23). The psychological and emotional demands of sports, particularly during high-stakes competitions, are also relevant and may increase heart rate substantially and unpredictably.

THE EFFECT OF IMPACT AND CONSIDERATIONS FOR ANTICOAGULATION

Athletes with cardiovascular disease who are taking anticoagulant drugs (vitamin K antagonists, direct thrombin or factor Xa inhibitors) must also consider the risk for impact during practice or competition. An impact that occurs while taking anticoagulation medication increases the risk of severe injury, especially for intracranial hemorrhage. Human-human or human-object impacts occur in many sports. Indeed, there are some sports in which impact is a key component of the game, such as American football and ice hockey. Conversely, there are some sports in which impact is extremely unlikely to occur, such as golf or track and field. For other sports, the risk and occurrence of impact are related to the age and competitiveness of the athletes. In these sports, such as basketball and soccer, the older the person and the more competitive the play, the more likely these people will undergo impacts. The **Table** divides sports according to the age of the athlete and the relative risk for impact.

Intracranial hemorrhage risk is possibly best ascertained by concussion incidence in sports; however, concussion incidences are certainly an underrepresentation of severe head injuries. Many head injuries do not result in concussion but nevertheless could put the person at a higher risk of intracranial bleeds if the person has been undergoing treatment with an anticoagulant agent. In high school athletes, concussion incidence is highest in American football (≈23/10,000 exposures), followed by ice hockey, lacrosse, soccer, basketball, and wrestling (24,25). Concussion risk is much higher in competition than in practice, with most concussions occurring as a result of player-player contact (70% of the concussions) or player-surface contact (17%) (24,25). Severe injuries not limited to head injury (defined as injuries that resulted in >21 lost days of sports participation) show a similar frequency distribution, with American football being most common (≈20/10,000 exposures) (26).

TABLE Sports According to Risk of Impact and Educational Background

	Junior High School	High School/College
Impact expected	American football Ice hockey Lacrosse Wrestling Karate/judo Fencing Boxing	American football Soccer Ice hockey Lacrosse Basketball Wrestling Karate/judo Downhill skiing Squash Fencing Boxing
Impact may occur	Soccer Basketball Field hockey Downhill skiing Equestrian Squash Cycling	Field hockey Equestrian Cycling Baseball/softball Gymnastics Figure skating
Impact not expected	Baseball/softball Cricket Golf Riflery Gymnastics Volleyball Swimming Track and field Tennis Figure skating Cross-country skiing Rowing Sailing Archery Weightlifting Badminton	Cricket Golf Riflery Volleyball Swimming Track and field Tennis Cross-country skiing Rowing Sailing Archery Weightlifting Badminton

Recommendations

1. **The risk of bleeding with athletes receiving vitamin K antagonists or direct thrombin or factor Xa inhibitors is increased in sports in which impacts may occur, and athletes should be cautioned to avoid these sports *(Class IIb; Level of Evidence C)*.**
2. **Athletes taking vitamin K antagonists or direct thrombin or factor Xa inhibitors should not participate in sports with impact expected, because the risk of intracranial hemorrhage is increased *(Class III; Level of Evidence C)*.**

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Writing Group Disclosures

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Reviewer Disclosures

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