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Cardiovascular pre-participation screening and risk assessment in the masters athlete: International recommendations and a Canadian perspective

More evidence is needed to determine the best strategies to mitigate risk of adverse cardiovascular events during exercise for those older than 35.

ABSTRACT: Although routine physical activity is associated with health benefits, there is also a transient increased risk of adverse cardiovascular events during vigorous physical activity. Methods to detect disease and ensure that athletic pursuits are safe and appropriate have been proposed. However, for competitive athletes older than 35 years—masters athletes—debate about the optimal battery of tests for comprehensive risk assessment has been considerable. While the use of tools such as the Physical Activity Readiness Questionnaire for Everyone is standard, some agencies recommend more comprehensive risk assessment processes, and screening protocols vary widely across the world. Along with some form of pre-participation screening, risk-mitigating strategies might include educating masters athletes to exercise safely, to report new and unusual symptoms for evaluation, and to consider preventive health habits (e.g., monitor blood pressure and lipid levels, maintain healthy body weight). Other strategies might include modifying exercise for high-risk individuals, ensuring emergency procedures are in place, and installing automated external defibrillators in all sporting venues. Developing pre-participation screening and risk assessment recommendations for Canada's heterogeneous population will require a better understanding of cardiovascular disease prevalence and more evidence regarding the effectiveness of proposed pre-participation screening procedures for the masters athlete.

This article has been peer reviewed.

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Routine physical activity is associated with improved health and well-being and a reduction in adverse cardiovascular events and all-cause mortality, while physical inactivity is known to be a risk factor for the development of cardiovascular disease (CVD) and premature mortality.[1] Physical inactivity is associated with at least 25 chronic medical conditions.[1] However, there is also a transient increased risk of adverse cardiovascular events during vigorous physical activity, especially for masters athletes—those older than 35 years involved in recreational and

competitive athletics at a high level. Many of these individuals participate in athletic endeavors for a variety of reasons: improved self-image, love of competition, enjoyment of camaraderie, and stress reduction.

Despite the proven health benefits of exercise, there is also clear evidence that an acute bout of exercise transiently increases the risk for potentially life-threatening events such as myocardial infarction, aortic dissection, arrhythmia, sudden cardiac arrest, and sudden cardiac death.[2,3] In a recent study of sports-related deaths in the general population age 10 to 75 from 2005 to 2010 in France, researchers found 90% of cases occurred during recreational sport. The mean age in the sudden death cases was 46 ±15 years.[4] To mitigate risk and ensure activities are safe and appropriate in both recreational and competitive athletics, strategies such as pre-participation screening and cardiovascular risk assessment have been proposed.[5] When attempting to reduce the risks associated with exercise for masters athletes, there are some unique considerations.

Who is at risk?
Sudden cardiac death (SCD) is defined as death that occurs unexpectedly within an hour or less of the onset of symptoms.[3] In the masters athlete 35 years and older the primary cause of sudden cardiac death is atherosclerotic disease, whereas in the athlete younger than 35 years genetic or congenital cardiovascular abnormalities are predominately responsible.[5,6] The common feature of SCD in younger and older athletes is lack of symptoms for any underlying CVD.

The transient risks associated with an acute bout of exercise appear to be the greatest in physically inactive individuals who engage in vigorous-intensity activities; that is, exercise that

involves expending 6 METs (metabolic equivalent tasks), a measure of more than 21 mL of oxygen per kg per minute.[2,3] Moreover, the risk of sudden cardiac death can be attenuated greatly with regular activity. For instance, when Siscovick and colleagues compared the risk of cardiac arrest during exercise and during rest,

they found that the relative risk (RR) during exercise was 5-fold higher in highly active individuals and 56-fold higher in those with the lowest activity levels.[2] Albert and colleagues also demonstrated that habitually active men (i.e., those who exercise at least 5 times per week) have a much lower relative risk of sudden cardiac death (RR = 10.9) than men who exercise vigorously less than once a week (RR = 74.1).[3] Interestingly, compared to risk during periods of mild or no physical activity, vigorous physical activity transiently increased the risk of sudden cardiac death from a factor of 14 to 45. This risk remained elevated in even the most active men. Importantly, despite these increased risks the evidence is clear that the lifetime risks for adverse cardiovascular-related events are markedly lower in active individuals across the lifespan.[2,3]

Current screening recommendations
Various pre-participation screening and risk stratification tools are currently available. These range from self-administered questionnaires to protocols involving assessment by health care professionals.[7,8] These questionnaires and protocols were

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developed for use in the general population, but have been incorporated into most athletic settings. Leading agencies such as the American Heart Association (AHA), the American College of Sports Medicine (ACSM), and the American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR) have developed important screening recommendations for the general population.[9] Pre-participation screening and risk stratification before the start of an activity program (i.e., physical activity clearance) or before exercise testing have significant medicolegal implications and are widely considered standard practice.[7,8,10] Recent advances in screening and risk stratification with the use of the Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) and the electronic Physical Activity Readiness Medical Examination (ePARmed-X+) have greatly

Table. Two approaches to recommendations for physical activity clearance and pre-participation screening in athletes.

Physical activity clearance

- Physical Activity Readiness Questionnaire for Everyone (PAR-Q+)
- Electronic Physical Activity Readiness Medical Examination (ePAR-Q+)
- AHA/ACSM Health/Fitness Facility Pre-participation Screening Questionnaire

Pre-participation screening

	Individual approach (European Association of Cardiovascular Protection and Rehabilitation)	**Selective approach** (American Heart Association)
Eligibility for pre-participation screening	• All adult/senior nonprofessional athletes engaged in vigorous activity • Athletes engaged in moderate activity whose physical activity clearance assessment (i.e., results from PAR-Q+ or AHA/ACSM questionnaires) has identified risk	• All masters athletes > 40 years
Pre-participation screening components	• History • Physical examination • Systematic COronary Risk Evaluation (SCORE) • Resting ECG	• History • Physical examination • Resting ECG
Criteria for maximal treadmill exercise testing	• Presence of alarming symptoms • Abnormal physical examination results • High-risk SCORE profile • Abnormal resting ECG	• Symptoms suggestive of coronary artery disease • Moderate to high cardiovascular risk profile: men > 40 years, women > 50 years with ≥ 1 risk factor • All athletes ≥ 65 years

reduced the barriers to physical activity participation for apparently healthy individuals and those with established chronic medical conditions across the lifespan.[7,8]

Components of screening for athletes

Owing to medicolegal requirements, the completion of simple questionnaires such as the PAR-Q+ and the AHA/ACSM Health/Fitness Facility Pre-participation Screening Questionnaire is considered standard when working with young competitive and masters athletes.[7,8,10] However, many agencies have recommended more comprehensive risk assessment batteries. This has led to considerable debate and pre-participation screening recommendations and protocols that vary widely across agencies and countries. For instance, there are clear differences in the pre-participation

screening recommendations of the European Association of Cardiovascular Prevention and Rehabilitation (EACPR) and the American Heart Association (**Table**).[6,9] The EACPR suggests an individual approach, in which the level of testing required depends on the intended level of physical activity/exercise and the risk determined by self-assessment (i.e., results from the PAR-Q+ or AHA/ACSM questionnaires).[9] By contrast, the AHA recommends a selective approach involving a history, physical examination, and resting ECG for all masters athletes, and a maximal exercise treadmill test for masters athletes who are older than 40 (men) or 50 (women) and have one additional cardiovascular risk factor.[6] The issue of cardiovascular pre-participation screening has been the topic of discussion in a number of countries, but there have been no contributions

yet from any notable Canadian health organizations.

Cardiovascular risk score

The use of cardiovascular risk scores to determine a person's 10-year risk of CVD has been widely accepted and varies slightly from one country to another. In Europe, the Systematic COronary Risk Evaluation (SCORE) system takes into account age, sex, blood pressure, cholesterol levels, and smoking history.[9] An individual is considered high risk if he or she has one of the following: a 10-year risk score higher than 5%, elevated total blood cholesterol (above 8 mmol), elevated LDL cholesterol (above 6 mmol), elevated blood pressure (greater than 180/110 mm Hg), diabetes with microalbuminuria, family history of premature CVD in first-degree relatives younger than age 50, or a BMI greater than 28. Simi-

larly, the United States and Canada use the Framingham risk score (FRS) in 30- to 74-year-olds with unknown CVD. The FRS is calculated using the patient's age, blood pressure, total cholesterol level, HDL cholesterol level, smoking history, and knowing whether the patient is taking medication for blood pressure.[11] The latest modified FRS also takes into account whether the patient has a history of premature CVD, which results in a doubling of the FRS in those age 30 to 59, and whether CVD is present in a first-degree relative younger than 55 (men) and 65 (women). The patient's risk is categorized as either low (0% to 9%), intermediate (10% to 19%), or high (20% or more). Consensus groups strongly recommend that cardiovascular risk be assessed routinely, with the frequency depending on the presence and severity of risk markers.[11] Studies show the greatest improvement in cardiovascular risk occurs when risk profiles are discussed with and given to the patient.[11]

Psychological stress assessment
Psychological stress has been associated with the development of premature CVD. The INTERHEART study found that psychological stress was the third-highest risk factor for an acute myocardial infarction, ranking behind only smoking and elevated lipid levels.[12] Psychological stress may contribute to CVD risk by activating the sympathetic nervous system. Therefore, assessment of patients' exposure to both repeated acute mental stress and chronic stress may be useful in determining their risk of developing CVD.

Symptoms, family history, and physical examination
The AHA 14-element guidelines for cardiovascular screening of athletes have been used in young competitive athletes.[5] A meta-analysis examining the utility of family history and physical examination in screening for CVD reported a low sensitivity of 20% for family history and 9% for physical examination.[13] Undoubtedly, this leads to high false-positive rates and subsequent physician referrals. In the masters athlete, the effectiveness of family history and physical examination in screening has not been established, and the sensitivity of these tools in this population is unknown. Given that the primary cause of sudden cardiac death in athletes older than 35 is coronary artery disease (CAD), it is important to ask about specific symptoms during history taking (e.g., angina, syncope, or presyncope during or after exertion; unusual fatigue; dyspnea; palpitations) and to determine if there is a family history of cardiovascular disease. The physical examination is important for detecting valvular disease and hypertension, which are highly prevalent in masters athletes.[14,15] However, studies have shown cardiovascular physical examination to have high interobserver variability, which limits its usefulness as an initial screening tool.[16] Physician availability and concomitant cost are other barriers.

Resting 12-lead electrocardiogram
The ongoing debate between European and US sports cardiology experts on whether or not to include a resting 12-lead ECG in pre-participation screening resides in concerns about the sensitivity and specificity of the test and justification for the cost.[5] Subclinical cardiac disease such as prior myocardial infarction, left ventricular hypertrophy, and fibrosis, as well as many cardiovascular diseases (e.g., arrhythmias, ion channelopathies, arrythmogenic right ventricular cardiomyopathy, hypertrophic cardiomyopathy) are clinically silent and can be detected by ECG before symptom onset.[14,15,17,18] Supporters of ECG use in screening maintain that the history and physical examination alone have marginal value in identifying those at risk for sudden cardiac death, while other experts maintain the ECG cannot accurately detect flow-limiting coronary artery disease, and yet others recommend exercise treadmill testing to screen for CAD in an asymptomatic population.[6]

Concerns that screening with an ECG will result in a high false-positive rate when physiologically normal training-related abnormalities are considered pathological can be addressed by ensuring the ECG is analyzed by a sports cardiologist and according to the latest criteria.[17] Training-related ECG patterns can be observed in 60% to 80% of athletes and include bradycardia, sinus arrhythmia, first-degree atrioventricular block, early repolarization, incomplete right bundle branch block, and voltage criteria for left ventricular hypertrophy.[18] These abnormalities can occur as a result of intense physical training over months or years, and should be evaluated with respect to age, gender, ethnicity, level of training/competition, workload of the sport, and aerobic capacity specific to the sport. For example, endurance training and sports such as running, cycling, cross-country skiing, and rowing/canoeing are associated with eccentric remodeling (ventricular dilation coupled with increase in ventricular wall thickness), while strength training is associated with concentric remodeling (increased left ventricular wall thickness) and increased systolic and diastolic blood pressure.[19] Both forms of cardiac remodeling have been termed "athlete's heart" and can elicit voltage criteria for left ventricular hypertrophy

on ECG.[18] Individuals with left ventricular hypertrophy on 12-lead ECG do not require follow-up unless the pattern of hypertrophy is accompanied by other non-voltage criteria or they have other risk factors suggestive of CVD (e.g., long-standing high blood pressure).[18]

Exercise treadmill test

With its proven ability to predict arrhythmias and flow-limiting CAD, the exercise treadmill test has been proposed as a prognostic tool for stratifying risk for sudden cardiac death because it can be used to assess the degree of ST segment depression, hypotensive blood pressure response, hypertensive blood pressure response, complex ventricular ectopy, and reduced exercise capacity. The Framingham Offspring Cohort study examined subjects with no history of CAD and discovered that failure to reach target heart rate and exercise tolerance (METs achieved), were strong predictors of CAD risk in men and women after adjustment of their cardiovascular risk score.[20] Mora and colleagues emphasized the utility of stratifying risk for female participants using the exercise treadmill test, demonstrating that ST segment response did not predict future risk for CAD events, whereas low exercise capacity and low heart rate recovery after exercise were independent predictors of death from CAD (RR 3.52) and all-cause mortality (RR 2.11).[21]

Unfortunately, the exercise treadmill test has been criticized for having a high rate of false-positives in detecting CAD in asymptomatic patients with low likelihood of the disease. In males, however, the predictive value improves as the number of cardiovascular risk factors increases. For example, the age-adjusted relative risk of an abnormal exercise test for CAD death was 21 in those with no risk factors, 27 in those with one risk factor, 54 in those with two risk factors, and 80 in those with three or more risk factors.[22] A truly positive exercise treadmill test requires the presence of a flow-limiting coronary lesion, whereas most acute coronary events evolve from a vulnerable plaque rupture at points of mild to moderate stenosis and are less likely to be detected on such a test.[6] In athletes who have a high fitness level (maximal exercise tolerance greater than 10 METs) and a moderate to high risk of CVD, disease and associated symptoms can be masked on an exercise treadmill test, suggesting that imaging tests should be considered in the event of an exercise treadmill test without significant findings.[23]

Other screening options

Cardiovascular imaging as a first-line option in screening may not be appropriate because of concerns about cost-effectiveness, accessibility, and radiation exposure. However, improvements in cardiovascular imaging technology coupled with improvements in therapeutic options for CVD have led to greater interest in cardiovascular imaging options for pre-participation screening.[23]

Echocardiogram

Many privately funded professional organizations such as the International Federation of Association Football, the International Cycling Union, and the US National Basketball Association include echocardiography as part of first-line screening, whereas scientific associations such as the European Society of Cardiology (ESC) and the American Heart Association do not include echocardiography in their recommended screening processes.

Echocardiography is relatively inexpensive, accessible, and unlikely to cause direct adverse effects. It can detect disorders not always evident on an ECG, such as coronary anomalies, proximal aortic dilation, bicuspid aortic valve, mitral valve prolapse, some cardiomyopathies, and other forms of left ventricular dysfunction, making it a logical modality for pre-participation screening.[23] However, discriminating between physiological and pathological cardiomyopathies in a high-level athlete can be difficult, and use of echocardiograms may inappropriately exclude athletes from competition or fail to reveal pathological disease with potential for sudden cardiac death.[23] Aagaard and colleagues included echocardiography along with a personal symptoms questionnaire, physical examination, and ECG when screening male endurance runners and confirmed that the echocardiograms did not reveal any disease that would place the athlete at risk for sudden cardiac death beyond the disease discovered using the ECG, physical examination, and personal symptoms questionnaire.[14] The echocardiogram could, however, play a prognostic role in identifying age-associated, subclinical CVD[24] and potentially permit stratification of risk for atrial fibrillation.[25]

Cardiac computed tomography and coronary artery calcium scoring

Currently, cardiac computed tomography (CCT) and coronary artery calcium scoring (CACS) are not recommended for pre-participation screening, but consensus groups support their use in asymptomatic individuals with intermediate (10% to 20%) or low cardiovascular risk (less than 10%) with a positive family history for premature CAD.[11]

CCT is a highly sensitive test (99%; 95% credible interval 97% to 99%) for detecting clinical and subclinical CAD (less than 50% stenosis),

with a very high negative predictive value (median 100%, range 86% to 100%).[26] Although not recommended for use in low-risk athletes (e.g., marathon runners) evidence shows CCT can play a role in detecting low to moderate stenosis in an active, fit, asymptomatic athlete.[27] In one study, CCT detected mild to moderate CAD in approximately 50% of male marathon runners, while the exercise treadmill test failed to detect any CAD in these same runners.[27] Both CCT and CACS have prognostic value over routine risk factors for predicting cardiac events, which could be beneficial in stratifying and managing risk in categories above 10% by altering treatment decision making (e.g., identifying those suitable for lipid treatment).[11] Additionally, the CACS may alter individual lifestyle behaviors and ultimately lower event rates without incurring significant downstream medical costs.[28] While radiation exposure has been posed as a limitation, new technology has substantially reduced exposure, with a mean effective radiation dose of 0.30 mSv for CACS, which is approximately one-sixth of the radiation we are exposed to annually in Canada, and a dose of 1.26 mSv for CCT.[27] Larger-scale studies are needed to determine if the use of CCT or CACS leads to reductions in morbidity and mortality before either can be included as a screening tool.

Cardiac magnetic resonance imaging

Cardiac magnetic resonance (CMR) imaging is the most comprehensive imaging modality for excluding pathology and is the gold standard for examining cardiac function in patients and athletes.[23] It can distinguish between athlete's heart, dilated cardiomyopathy, and mild forms of hypertrophic cardiomyopathy.[29] As well, CMR has potential prognostic

value in the detection of subclinical myocardial fibrosis, which is a concern in chronic endurance exercisers.[30] However, because of limited availability, high cost, and the low pre-test probability of cardiac pathology in the athlete population, this test is less suitable for broad-based screening.[23,29] For athletes with an abnormal ECG result, especially when a cardiomyopathy, a coronary anomaly, or myocarditis is suspected, CMR plays a crucial role in diagnosis.[23]

Conclusions

The risk of adverse cardiovascular events during exercise increases with age because of the greater prevalence of atherosclerotic disease in those older than 35. More evidence is needed to determine the best strategies to mitigate risk. In addition to pre-participation screening, strategies might include educating masters athletes to exercise safely, to promptly report new and unusual symptoms for evaluation, and to consider preventive health habits (e.g., monitor blood pressure and lipid levels, maintain healthy body weight). Other strategies might include modifying exercise for high-risk individuals, ensuring emergency procedures are in place, and installing automated external defibrillators in all sporting venues.

The risk of adverse cardiovascular events during exercise increases with age because of the greater prevalence of atherosclerotic disease in those older than 35.

Current protocols used around the world have yet to be systematically and extensively evaluated. Furthermore, the risk characteristics of Canada's unique, heterogeneous population have not been established. Before Canadian recommendations can be developed, a better understanding of CVD prevalence and more data regarding the effectiveness of proposed screening procedures will be needed.

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