

Systematic Review/Meta-analysis

The Acute Risks of Exercise in Apparently Healthy Adults and Relevance for Prevention of Cardiovascular Events

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Background: Increased physical activity (PA) is associated with improved quality of life and reductions in cardiovascular (CV) morbidity and all-cause mortality in the general population in a dose-response manner. However, PA acutely increases the risk of adverse CV event or sudden cardiac death (SCD) above levels expected at rest. We review the likelihood of adverse CV events related to exercise in apparently healthy adults and strategies for prevention, and contextualize our understanding of the long-term risk reduction conferred from PA.

Methods: A systematic review of the literature was performed using electronic databases; additional hand-picked relevant articles from reference lists and additional sources were included after the search.

Results: The incidence of adverse CV events in adults is extremely low during and immediately after PA of varying types and intensities and is significantly lower in those with long-standing PA experience. The risk of SCD and nonfatal events during and immediately after PA remains extremely low (well below 0.01 per 10,000 participant hours);

RÉSUMÉ

Introduction : L'augmentation de l'activité physique (AP) est associée à l'amélioration de la qualité de vie et à la diminution de la morbidité cardiovasculaire (CV) et de la mortalité toutes causes confondues dans la population générale selon une relation dose-réponse. Cependant, l'AP augmente considérablement le risque d'événements CV indésirables ou la mort cardiaque subite (MCS) au-dessus des niveaux attendus au repos. Nous passons en revue la probabilité d'événements CV indésirables liés à l'exercice chez les adultes apparemment en santé et les stratégies de prévention, et contextualisons notre compréhension de la diminution des risques à long terme que confère l'AP.

Méthodes : Nous avons réalisé une revue systématique de la littérature à partir des banques de données électroniques. Nous avons inclus des articles pertinents additionnels triés sur le volet provenant de listes de référence et de sources complémentaires après la recherche.

The cardiovascular (CV) health benefits conferred by increased habitual physical activity (PA) are now widely accepted.^{1,2} Current evidence supports a dose-response pattern, largely indicating that optimum risk reduction is achieved with vigorous PA.^{3–6} Exercise intensity of various PA types is typically quantified using metabolic equivalents (METs), or the rate at which the body expends energy above rest (1 MET = 3.5 mL of oxygen per kilogram of body mass per minute), with vigorous exercise considered to be greater than 6 METs, as outlined in the compendium of physical activities published by the American College of Sports Medicine.⁷ However, although such classification is applicable to

the general untrained population, those engaged in regular vigorous exercise commonly perform exercise well above 8 METs, with trained athletes often exceeding an intensity of 12–15 METs for a sustained time period.^{7,8} Nonetheless, early observations suggested a linear relationship between increasing energy expenditure and low mortality rates through vigorous PA of at least 4187 J/wk (1000 kcal/wk), but optimally closer to 8374 J/wk (2000 kcal/wk) yield the greatest risk reductions for CV disease (CVD) mortality.^{4,6} More recent data largely confirm these findings but show that numerous health benefits at the population level might be conferred from lesser volumes of PA. Decreased all-cause and CV mortality rates have been observed with as little as 30–59 min/wk of jogging,⁹ as well as either an attenuation or threshold effect^{10,11} or a loss of cardioprotection at very high levels of PA.^{12,13}

Notwithstanding the health benefits of moderate to intensive PA, adverse CV events, particularly sudden cardiac death (SCD) during or immediately after exercise, pose concerns for participants and health practitioners alike. Such events are accompanied by considerable media attention because victims are performing the very activity purported to

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increasing age and PA intensity are associated with greater risk. In most cases of exercise-related SCD, occult CV disease is present and SCD is typically the first clinical event.

Conclusions: Exercise acutely increases the risk of adverse CV events, with greater risk associated with vigorous intensity. The risks of an adverse CV event during and immediately after exercise are outweighed by the health benefits of vigorous exercise performed regularly. A key challenge remains the identification of occult structural heart disease and inheritable conditions that increase the chances of lethal arrhythmias during exercise.

reduce the likelihood of CVD, often occurring without warning or prodrome. However, only 4%-17% of SCD cases are linked to physical exertion in men older than 35-40 years, with much lower rates observed for women.^{14,15} The observations of CV risk reduction through chronic exercise and the acutely increased risk of adverse cardiac events has been termed risk-paradox of exercise.¹⁶⁻²⁴

In this review the likelihood of adverse events in the exercise and the immediate period after exercise in the apparently healthy adult who has no previous diagnosis of heart disease is examined, and this risk contextualized within the broader understanding of long-term risk reduction from PA participation. To this end, we summarize findings related to the acute triggers associated with exercise-induced cardiac arrest, acute myocardial infarction, serious ventricular arrhythmias, and in particular, SCD during and immediately after PA, often termed the periection period. Other CV events arising from known clinical conditions (eg, myocarditis, pericarditis, heart failure, pulmonary edema) are beyond the scope of this review, because individuals with these conditions are likely considered to be at increased risk and not 'apparently healthy'.²² Although the focus of this review is primarily on aerobic PA (eg, running, cycling, swimming), we also summarize the limited evidence of risk from other types of exercise (eg, resistance exercise). Collectively, these findings are important in guiding clinicians and allied health professionals in providing appropriate guidance to healthy adults toward continuing or increasing their participation in vigorous PA. Our review expands considerably a previous review that provided a rationale for revising preparticipation screening procedures to reduce the barriers to PA,²² on the basis of the relatively low risk of adverse cardiac events during PA, also recently echoed by the American College of Sports Medicine in a revision of their preparticipation screening algorithm.^{24,25}

Methods

A systematic literature review was performed using the following electronic databases: MedLine, CINAHL, SPORT Discus, EMBASE, Cochrane Database of Systematic Reviews, American College of Physicians Journal Club, and DARE. All

Résultats : L'incidence des événements CV indésirables chez les adultes est extrêmement faible durant et immédiatement après l'AP de types et d'intensités variables, et est significativement plus faible chez ceux qui ont une expérience de longue date de l'AP. Le risque de MCS et d'événements non fatals durant et immédiatement après l'AP demeure extrêmement faible (bien au-dessous de 0,01 par 10 000 heures de participation); l'avancement en âge et l'intensité de l'AP sont associés à un risque plus élevé. Dans la plupart des cas de MCS liée à l'exercice, la maladie CV occulte est présente et la MCS est généralement le premier événement clinique.

Conclusions : L'exercice augmente considérablement le risque d'événements CV indésirables, dont un risque plus élevé associé à l'exercice d'intensité vigoureuse. Les avantages de la pratique régulière de l'exercice vigoureux sur la santé sont supérieurs aux risques de subir un événement CV indésirable durant et immédiatement après l'exercice. Le défi primordial demeure la détection de la cardiopathie structurelle occulte et les affections héréditaires qui augmentent les risques d'arythmies létales au cours de l'exercice.

articles were screened for applicability as well as additional references. Terms were included in the search that covered exercise or PA risk, cardiac sudden death, myocardial infarction, syncope, and exercise syncope. The main search was further supplemented with articles identified by the authors if not captured by electronic searches.

Pathophysiology of Exercise-Induced Adverse CV Events

The pathophysiology underlying exercise-induced SCD has been well described and theorized.²⁶⁻³⁰ In health, adequate coronary blood flow reserve and normal cardiac electrical activity occur during vigorous exercise. However, in the presence of coronary artery disease, the production of malignant substrates during or immediately after exercise stress might trigger a cascade of physiological events precipitating an adverse event (Fig. 1). Most exercise-related SCD cases in individuals older than 30-35 years of age are secondary to acute complications of atherosclerosis, which is associated with > 80% of exercise-related SCD in individuals older than 35 years of age, and > 95% of cases when the age exceeds 40 years.³¹⁻³⁵ Autopsy findings generally indicate acute myocardial infarction, but evidence of coronary thrombosis is not always identifiable. Exercise stress is considered to be a risk factor for acute and vulnerable atherosclerotic plaque,^{33,36-38} likely by accelerating the fissuring of fragile, nonocclusive plaque secondary to mechanisms that remain unclear. Altered geometric and hemodynamic states of epicardial arteries (eg, increased shear stress or geometry), might in turn lead to plaque disruption. Plaque rupture might also be spontaneously induced through increased fibrinolytic activity triggered by a prothrombotic state induced by vigorous,^{14,39,40} but not moderate⁴⁰⁻⁴² exercise.

The identification of disease presence (or severity) remains a key limiting factor in the prevention of adverse outcomes because previous symptoms are absent in most cases of exercise-related SCD. This is also true for preparticipation screening, which might mitigate some, but not all cases of SCD.³² In SCD cases involving younger individuals (eg,

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