

Effects of Running on Chronic Diseases and Cardiovascular and All-Cause Mortality

Carl J. Lavie, MD; Duck-chul Lee, PhD; Xuemei Sui, MD, PhD, MPH;
Ross Arena, PhD, PT; James H. O’Keefe, MD; Timothy S. Church, MD, PhD;
Richard V. Milani, MD; and Steven N. Blair, PED

Abstract

Considerable evidence has established the link between high levels of physical activity (PA) and all-cause and cardiovascular disease (CVD)—specific mortality. Running is a popular form of vigorous PA that has been associated with better overall survival, but there is debate about the dose-response relationship between running and CVD and all-cause survival. In this review, we specifically reviewed studies published in PubMed since 2000 that included at least 500 runners and 5-year follow-up so as to analyze the relationship between vigorous aerobic PA, specifically running, and major health consequences, especially CVD and all-cause mortality. We also made recommendations on the optimal dose of running associated with protection against CVD and premature mortality, as well as briefly discuss the potential cardiotoxicity of a high dose of aerobic exercise, including running (eg, marathons).

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Considerable evidence has established the link between high levels of physical activity (PA), regular exercise training (ET), and cardiorespiratory fitness (CRF) and the reduced long-term risk of various chronic diseases, including cardiovascular disease (CVD) and all-cause mortality.¹⁻⁶ Despite the known benefits of high levels of PA and ET, some evidence suggests that there may be a point of diminishing returns. In fact, there may be a threshold at which high doses of aerobic ET might detract from the remarkable health benefits of moderate ET or even induce cardiotoxicity.⁷⁻⁹

The current US guidelines for aerobic PA and ET suggest that all individuals should perform at least 150 min/wk of moderate PA, 75 min/wk of vigorous PA, or an equivalent of a combination of both.^{2,10} Running is a particularly attractive form of aerobic PA and ET that is generally regarded as a popular and practical high-intensity form of vigorous ET.^{11,12} Other evidence indicates that considerable benefits of aerobic PA and ET may be attained at levels well below those suggested by these national and international guidelines,¹¹⁻¹⁵ and, in fact, there may be cardiotoxicity of extreme exercise training (EET), such as prolonged, high-volume training

and competing in marathons, ultramarathons, or full distance triathlons.^{7-9,16}

In this review, we examine the evidence for the benefits of vigorous aerobic PA and ET, specifically running, for protection against various chronic diseases, including CVD and all-cause mortality. We also discuss the potential toxicity of a high dose of aerobic ET, including high levels of running. Finally, we make recommendations for running doses that are associated with maximal health benefits while diminishing the risk of cardiotoxicity, as well as make recommendations for advising and treating those who perform EET.

LINK BETWEEN PA, ET, CRF, AND PROGNOSIS

Considerable evidence suggests that physical inactivity, also referred to as a sedentary lifestyle, may be the greatest threat to health in the 21st century.¹⁻³ Despite the guidelines for PA, evidence suggests that a minority of adults in the United States and much of Western civilization are meeting these minimal PA recommendations.^{1-3,17} We have previously reported that a progressive decline in PA, especially in occupational and household PA, over the past 5 decades is a primary cause of the obesity epidemic that has been spreading in our society, and this also



From the Department of Cardiovascular Diseases, John Ochsner Heart and Vascular Institute, Ochsner Clinical School, School of Medicine, The University of Queensland, New Orleans, LA (C.J.L., R.V.M.); Department of Kinesiology, College of Human Sciences, Iowa State University, Ames (D.-c.L.); Department of Exercise Science, Arnold School of Public Health, University of South Carolina, Columbia (X.S., S.N.B.); Department of Physical Therapy and Integrative Physiology Laboratory, College of Applied Health Sciences, University of Illinois at Chicago, Chicago (R.A.); Saint Luke’s Mid America Heart Institute, University of Missouri-Kansas City, Kansas City, MO (J.H.O.); and Department of Preventive Medicine, Pennington Biomedical Research Center, Baton Rouge, LA (T.S.C.).

ARTICLE HIGHLIGHTS

- Considerable evidence suggests that physical inactivity may be the greatest threat to health in the 21st century.
- Substantial evidence indicates that low levels of cardiorespiratory fitness may be one of the strongest risk factors for cardiovascular disease.
- Runners typically perform vigorous physical activity and have high levels of cardiorespiratory fitness.
- We reviewed data that indicate that running has benefits in the prevention of obesity, hypertension, dyslipidemia, type 2 diabetes, osteoarthritis and hip replacement, benign prostatic hypertrophy, respiratory disease, cancer, and disability.
- Running, even in quite low doses, is associated with a substantial reduction in cardiovascular and all-cause mortality.
- High doses of running (eg, marathons) have the potential for cardiotoxicity, although these risks are relatively low.
- Maximal health benefits of running appear to occur at quite low doses, well below those suggested by the US physical activity guidelines.

impacts the health of the next generation and contributes to many chronic diseases and adverse CVD outcomes.¹⁸⁻²¹ Considerable evidence suggests that high levels of PA and ET are associated with improved clinical outcomes, beyond those expected on the basis of effects on traditional risk factors for CVD, suggesting that other factors (eg, autonomic function, preconditioning, and endothelial function) might also explain the marked benefits noted.^{1-3,5} This evidence comes from studies evaluating the effects of both leisure time PA and occupational PA on subsequent prognosis.^{1,2}

In addition, substantial evidence indicates that low levels of CRF may be one of the strongest risk factors for CVD.^{1,2,4,6} In fact, preserved levels of CRF are associated with favorable prognosis in most patient groups, including those with obesity, type 2 diabetes mellitus (T2DM), hypertension (HTN), and dyslipidemia (DLP).^{1,2,6} Patients with these disorders but with a favorable level of CRF generally have a considerably better prognosis than do unfit individuals without these disorders.^{1,2,6} Although there is an inherited non-PA component of CRF, which may contribute approximately 15% to 30% to the

overall CRF level,^{12,22} the major determinant of CRF is the amount and intensity of aerobic PA and ET. Although high levels of both PA and CRF predict a better prognosis, most studies indicate that CRF levels are a considerably better predictor of prognosis than are PA levels.^{1,2,6}

Although this review focuses on running, it is worth noting that running is typically associated with high levels of aerobic PA, well above the metabolic equivalent (MET) level of 7, and during the maximal exercise test, runners typically have exercise capacities well above the MET level of 10, which is a level of CRF that is particularly associated with a favorable prognosis.^{11,12,23-25} However, as discussed below, at least in runners, there may be a discordant relationship between CRF and prognosis.¹¹

MAJOR RUNNING STUDIES

Although many studies have assessed the impact of running on chronic diseases as well as CVD and all-cause mortality, this review focuses predominantly on prospective observational databases, including published findings from the National Runners' and Walkers' Health Study,²⁶⁻⁴³ the Running Aging Study,⁴⁴ the Copenhagen City Heart Study,^{13,14} and the Aerobics Center Longitudinal Study (ACLS).^{11,12} We reviewed studies published in PubMed since 2000 that included at least 500 runners and at least 5 years of follow-up so as to analyze the relationship between vigorous aerobic PA, specifically running, and major chronic diseases and/or CVD and all-cause mortality.

Impact of Running on Weight and Obesity

Williams²⁷⁻²⁹ published several studies on the impact of running on weight and obesity. In a study of 33,480 male runners and 14,211 female runners, the body mass index (BMI; calculated as the weight in kilograms divided by the height in meters squared) and waist circumference of runners who ran less than 3 km/d were significantly related to their parents' adiposity.²⁷ However, this relationship weakened significantly in those with higher doses of running. In fact, exceeding the minimal ET dose recommendation, runners (energy equivalent of 2-3 km/d) seemed to have a substantial reduction in the risk of inherited obesity.

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