Cardiorespiratory Fitness and Risk of Sudden Cardiac Death in Men and Women in the United States: A Prospective Evaluation From the Aerobics Center Longitudinal Study

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Abstract

Objectives: To examine the relation between cardiorespiratory fitness (CRF) and sudden cardiac death (SCD) in a large US adult population and to study the effects of hypertension, obesity, and health status on the relation of CRF with SCD.

Patients and Methods: A total of 55,456 individuals (mean age, 44.2 years; 13,507 women) from the Aerobics Center Longitudinal Study, a prospective observational investigation (from January 2, 1974, through December 31, 2002), were included. Cardiorespiratory fitness was assessed by a maximal treadmill test, and baseline assessment included an extensive set of measurements.

Results: There were 109 SCDs. An inverse risk of SCD was found across incremental CRF levels after adjusting for potential confounders. Participants with moderate and high CRF levels had 44% (hazard ratio, 0.56; 95% CI, 0.35-0.90) and 48% (hazard ratio, 0.52; 95% CI, 0.30-0.92) significantly lower risk of SCD, respectively, than did those with low CRF levels ($P<.001$). The risk of SCD decreased by 14% (hazard ratio, 0.86; 95% CI, 0.77-0.96) per 1-metabolic equivalent increase in the fully adjusted model. Hypertensive, overweight, or unhealthy individuals with moderate to high CRF levels had lower risks of SCD (ranging from 58% to 72% of lower risk) than did those with the same medical conditions and low CRF levels.

Conclusion: The risk of SCD in US men and women could be partially reduced by ensuring moderate to high levels of CRF independently of other risk factors and especially in those who are hypertensive, overweight, or unhealthy.

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Sudden cardiac death (SCD) is recognized as a relevant cause of mortality, which in many cases occurs in the general population without previous symptoms of any coronary heart disease (CHD).[1-3] Although 70% to 90% of the total incidence of SCD occurs in men, this cause of mortality has been documented in both sexes in individuals with a history of CHD or other major cardiovascular (CV) disease (CVD) risk factors and in those without a history of CHD or CVD.[2,4] Therefore, SCD constitutes an important public health problem with multiple risk factors.[5] Although numerous studies[6-8] have attempted to identify those factors that are associated with higher SCD risk for the general population, conclusive evidence on this point remains somewhat elusive.

A moderate to high level of cardiorespiratory fitness (CRF) has been associated with many CV benefits and has been established as a predictor of all-cause mortality in men and women.[9-12] Moreover, the use of treadmill protocols and estimation of workloads based on treadmill speeds and inclines, typically reported as estimated metabolic equivalents (METs), as an indirect measurement of oxygen consumption, has widely reported to accurately predict these associations.[9-12] However, only 1 study[13] focused on the relation between

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CRF and SCD, in which authors studied 2368 European middle-aged men and reported that CRF (cycle ergometer test) was inversely related to the risk of SCD. In addition, other authors studied the effect of specific risk factors, such as systemic blood pressure (BP) and hypertension (HTN)[14] and asymptomatic ST-segment depression[15] in men or a cluster of lifestyle factors in women,[16] on the risk of SCD.

One of the American Heart Association's 2020 Impact Goals[17] is to decrease CVD mortality. Thus, prevention of SCD by detecting early risk factors could be a useful tool contributing to the American Heart Association's goal through decreasing the incidence of SCD at the population level. The identification of these risk factors would facilitate the large-scale screening of those participants at higher risk of SCD. However, to our knowledge, there has been no large-scale prospective assessment of the relation between CRF and SCD, including men and women, and assessment of the effect of CRF, especially combined with the other important CVD risk factors. Therefore, the present study aimed to examine the relation between CRF and SCD in a large population of men and women in the United States. We also sought to study the specific effects of HTN, obesity, and overall health status on the relation of CRF with SCD.

PATIENTS AND METHODS

The present report is based on data from the Aerobics Center Longitudinal Study, a prospective observational investigation into the association of clinical and lifestyle factors with disease and health outcomes in patients examined at the Cooper Clinic in Dallas, Texas.[11,17]

Participants came to the clinic for periodic preventive health examinations and for counseling on diet, exercise, and other lifestyle factors associated with an increased risk of chronic disease. Participants were volunteers, not paid, and were not recruited into the study, but sent by their employers or physicians or were self-referred for the examination. The Cooper Institute's institutional review board reviewed and approved the study protocol annually.

For the present analysis, participants 20 years and older with complete data on CRF and a group of potential confounders including health behaviors, blood parameters, and disease-related information were included. From a total of 59,611 participants, we excluded those who failed to achieve at least the 85% of age-predicted maximum heart rate during the treadmill test (n=1868) or were followed for less than 1 year (n=2287). These criteria resulted in 55,456 individuals (13,507 women) with a mean age of 44.2 years (ranging from 20 to 100 years), whose baseline examination occurred from January 2, 1974, through December 31, 2003. Participants were predominantly white, well-educated, and belonged to the middle and upper socioeconomic strata.

Outcomes and Follow-Up

Procedures of the clinical examinations are described in detail elsewhere.[11,18] Briefly, the baseline assessment was performed after an overnight fast and included an extensive physical examination and an array of clinical measurements. Body mass index (BMI) was calculated as the weight in kilograms divided by the height in meters squared (kg/m^2) and measured using a standard clinical scale and stadiometer. *Overweight* and *obesity* were defined as a BMI of 25 to 29.9 and 30 or more kg/m^2, respectively. Resting systolic and diastolic BP was measured in the seated position as the first and fifth Korotkoff sounds by using standard auscultation methods after at least 5 minutes of sitting quietly and recorded as the average of at least 2 readings separately by 2 minutes.[19] If the first 2 readings differed by more than 5 mm Hg, additional readings were obtained and averaged; *HTN* was defined as systolic or diastolic BP of 140/90 mm Hg or greater or a history of physician diagnosed HTN. Concentrations of total cholesterol and fasting glucose were measured using automated techniques in accordance with the standards of the Centers for Disease Control and Prevention lipid standardization program. *Hypercholesterolemia* was defined as a serum total cholesterol level of 240 mg/dL or greater (to convert to mmol/L, multiply by 0.0259). *Diabetes mellitus* was defined according to the American Diabetes Association criteria,[20] that is, a fasting plasma glucose level of 126 mg/dL or greater, use of insulin, or self-report of previous physician diagnosis. Participants completed a standardized questionnaire on medical history that

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