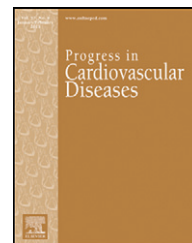


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Physical Activity Versus Cardiorespiratory Fitness: Two (Partly) Distinct Components of Cardiovascular Health?

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ABSTRACT

Physical activity (PA) and cardiorespiratory fitness (CRF) both have inverse relationships to cardiovascular (CV) morbidity and mortality. Recent position papers and guidelines have identified the important role of both of these factors in CV health. The benefits of PA and CRF in the prevention of CV disease and risk factors are reviewed. In addition, assessment methodology and utilization in the research and clinical arenas are discussed. Finally, the benefits, methodology, and utilization are compared and contrasted to better understand the two (partly) distinct components and their impact on CV health.

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The cardiovascular (CV) health benefits of physical activity (PA) and cardiorespiratory fitness (CRF) are well established. They are associated not only with lower CV disease (CVD) morbidity and mortality, but also with lower prevalence of risk factors for CVD such as diabetes, hypertension and selected dyslipidemias.¹ In 1992, the American Heart Association (AHA) identified physical inactivity as a major risk factor.² Then in 2010, the AHA included ideal levels of PA as one of the key 7 preventive health factors and behaviors.³ Public health and clinical guidelines for promoting PA have been published by several national associations⁴ and the federal government (<http://www.health.gov/paguidelines/guidelines/default.aspx>).

The inverse association between CRF and all-cause as well as CVD mortality has been reported for a variety of different populations starting in the 1980s.⁵ This association between CRF and CVD mortality exists in younger and older men and women of different race/ethnicities, and is reasonably independent of other major CVD risk factors, including cigarette smoking, blood pressure, blood lipids, obesity and diabetes.^{5,6} While the link between decreased CRF and increased CVD risk is now well established, no national guidelines have been published for CRF as a CVD risk factor or for its use in risk assessment. The value of CRF as a clinical and public health tool for use in risk identification and classification recently was reviewed in a policy statement regarding the need for a

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Abbreviations and Acronyms

AHA = American Heart Association

CCLS = Cooper Center Longitudinal Study

CRF = cardiorespiratory fitness

CV = cardiovascular

CVD = cardiovascular disease

CHD = coronary heart disease

METs = metabolic equivalents

O₂ = oxygen

PA = physical activity

RR = relative risk

VO_{2max} = maximal oxygen consumption

national CRF registry published by the AHA.⁷ The authors state, “Although CRF is recognized as an important marker of both functional ability and cardiovascular health, it is currently the only major risk factor that is not routinely and regularly assessed in either the general or specialized clinical setting.” Others have expressed a similar view over the past decade.⁶

The question of the possible superiority of CRF versus PA in CVD risk assessment, research and public

health recommendations remains incompletely answered. The aim of this review is to provide insight into the CV health benefits from PA and CRF and the distinct strengths of each in research and clinical practice.

Physical activity and cardiovascular health

In 1953, Dr. Jerry Morris’ publication in the *Lancet* compared physically active London bus conductors to physically inactive bus drivers and found a decreased risk of coronary heart disease (CHD) among the conductors who spent much of their day walking, standing, and climbing steps collecting tickets.⁸ Following in Dr. Morris’ footsteps, many investigations have generated strong evidence that PA is associated with decreased risk for CVD and its risk factors.^{9,10} In fact, Lee et al.¹⁰ found that the worldwide elimination of physical inactivity would remove 5.8% of CHD and increase longevity by 0.68 years.

In prospective cohort studies, the prevalence of metabolic syndrome, obesity and other CVD risk factors, non-fatal stroke, CHD,¹ and risk of CVD mortality¹¹ are inversely associated with PA. Similar findings have been confirmed in meta-analyses of existing data. He et al. showed that leisure-time PA was associated with a decreased risk of metabolic syndrome [high PA v. low: RR, 0.80, (95% CI, 0.75–0.85) and moderate vs. low: RR = 0.95, (95% CI 0.91–1.00)].¹² Further, a meta-analysis by Li⁹ revealed leisure-time PA was associated with a 20%–30% reduction in risk of CHD and stroke.

In spite of strong associations with CVD, subclinical atherosclerosis, as indicated by the presence of coronary artery calcium, does not appear to be associated with PA measured by either self-report or accelerometer.^{13,14} The relationship between PA and certain other CV conditions has not been consistent. For example, a recent meta-analysis shows no association between PA and atrial fibrillation.¹⁵

In general, strong evidence indicates that PA provides protection against the development of CVD and its risk factors to the extent that inclusion of PA level improves the ability of existing algorithms to predict risk in patients with CVD.¹⁶

Cardiorespiratory fitness and cardiovascular health

The concept of maximal oxygen (O₂) consumption (VO_{2max}) dates to 1923 when Hill and Lupton¹⁷ demonstrated a plateau in O₂ uptake above which further increases in exercise intensity produced no additional increase in O₂ uptake in healthy young men. The highest amount of O₂ consumed was felt to be constrained by “...the limitations of the circulatory and respiratory system...”. Thus, it was established that VO_{2max} represents the capacity of the CV and respiratory systems to transport O₂ to vital organs and skeletal muscle. For clinical purposes, CRF typically is reported as mlO₂•kg⁻¹•min⁻¹ or metabolic equivalents (METs), though because both of these are heavily influenced by body weight, obesity may complicate the interpretation of such CRF assessments.¹⁸

CRF is recognized as an important risk predictor for CV mortality, all-cause mortality, as well as CV morbidity.^{5,19,20} The landmark study by Blair et al.⁵ in 1989 demonstrated a strong independent association of CRF, estimated from maximal treadmill exercise test duration, with all-cause mortality where participants in the lowest 20 percent of CRF had significantly higher mortality rates and relative risk (RR) of mortality compared to the highest 20 percent [men: RR (95% confidence interval) 1.82 (1.38–2.40); women: 3.92 (1.39–11.04)]. This report and others demonstrate that the greatest benefit in risk is present when comparing very low levels of CRF with the next highest CRF levels.^{5,21} These findings have been extended to women and multiracial groups.^{5,22,23}

CRF is inversely associated with CVD mortality and CHD events.²⁰ Mid-life low CRF has been shown to be inversely associated with incident congestive heart failure after more than 20 years of follow-up²⁴ as well as the burden of chronic conditions affecting healthy aging.²⁵ CRF is also important in modifying the effect of traditional risk factors for CVD events. For instance, the association of metabolic syndrome to CVD mortality in men is modified by CRF.²⁶

Lee et al.²⁷ showed that young individuals with higher CRF were significantly less likely to develop coronary artery calcium over a 15 year observation period. The inverse association of CRF with coronary artery calcium in women, with an older mean age, was less evident.²⁸ As with PA, the association with other CV conditions such as atrial fibrillation has been inconsistent.²⁹

Thus, CRF shows parallel benefits compared to PA in relation to CVD outcomes and in terms of risk prediction, CRF has been shown to improve the classification beyond traditional risk factors as well as cumulative lifetime risk of CVD mortality.^{30,31}

Contrasting CRF and PA in relation to CV health

Since CRF can be modified through changes in routine PA, it is regarded as a surrogate for habitual PA.⁴ However, animal and

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