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Physical Activity and the Prevention of Cardiovascular Disease: From Evolution to Epidemiology

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Abstract For most of human history, the environmental demands of survival necessitated prodigious amounts of physical exertion. The avoidance of predators, hunting, gathering, and the literal "chopping wood and carrying water" of daily existence provided a wholesome dose of physical activity that obviated the need for deliberate exercise. Nevertheless, 21st century humans are now immersed within an environment explicitly designed to eliminate physical labor. Over the past century and especially the past 50 years, an accrual of epidemiological evidence has established that the unintended consequence of humankind's predilection for labor-saving contrivances is an epidemic of hypokinetically induced cardiovascular disease, morbidity, and mortality. This review surveys data from observational studies supporting the premise that physical activity, exercise training, and improvements in cardiorespiratory fitness are essential elements in the prevention and treatment of the cardiovascular diseases induced by an environment in which survival no longer obligates physical exertion. (Prog Cardiovasc Dis 2011;53:387-396)

Keywords: Epidemiology; Physical activity; Cardiovascular disease; Cardiorespiratory fitness

Sedentarism, epidemiology, and cardiovascular disease

Modern humans are immersed within an environment explicitly designed to eliminate physical labor. As a result, sedentary lifestyles have become a predominant and pervasive feature of industrialized nations. Concomitant with the rise in sedentarism has been an epidemic of chronic disease and mortality. The confluence of passive transportation, spectator-based entertainment, and a decrement in energy expenditure via occupational and household physical activity (PA) has engendered an increase in hypokinetically induced obesity and cardiovascular disease (CVD). Because human cardiovascular (CV) physiology evolved within an environment that obligated prodigious amounts of energy expenditure via physical exertion,[1] it is not surprising that a lack of PA has induced a host of morbidities.

Over the past 5 decades, a substantial accumulation of epidemiological and experimental data has established a causal relationship between low levels of occupational and/or leisure-time PA (LTPA) (ie, a sedentary lifestyle) and an increased risk of CVD.[2,3] The evidence for the cardioprotective effects of exercise and the importance of PA in primary prevention as well as an empirically supported treatment is now quite extensive. Accordingly, the American Heart Association has concluded that a sedentary lifestyle is a major modifiable risk factor for CVD.[4] Nevertheless, there exists a lack of implementation of PA interventions in the prevention and treatment of CVD.

This review begins with a brief overview of how anthropogenic alterations of the social and physical environments reduced the necessity of physical exertion to the point that the deliberate adoption of a physically

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Abbreviations and Acronyms

BMI = body mass index

CHD = coronary heart disease

CV = cardiovascular

CVD = cardiovascular disease

CRF = cardiorespiratory fitness

ET = exercise training

HTN = hypertension

LTPA = leisure-time physical activity

PA = physical activity

RR = relative risk

SR = self-report

active lifestyle is now essential for health and well-being. A survey of the benefits of PA, exercise training (ET), and cardiorespiratory fitness (CRF) in the prevention of CVD is presented, followed by a review of relevant issues in the implementation and prescription of PA or ET. In 1996, the National Institutes of Health Consensus Statement on Physical Activity and Cardiovascular Health defined PA as "bodily movement produced by skeletal muscle that requires energy expenditure and promotes health benefits."[5] Exercise training is a subset of PA and must be systematic and progressive. *Exercise training* was defined as "planned, structured, and repetitive bodily movement done to improve or maintain one or more components of physical fitness." *Cardiorespiratory fitness*, also known as aerobic fitness, is defined as the capacity to use atmospheric oxygen for cellular energy production via aerobic metabolism. This energy production supports the metabolic demands of all bodily functions as well as the skeletal muscle movements involved in all forms of PA. Cardiorespiratory fitness is an objective measure of habitual PA and, therefore, is a better predictor of overall CVD risk than self-reported PA. Fig 1 illustrates the degree to which the objective measurement of PA via CRF more accurately estimates the cardioprotective effects of PA.[6] Maximal and peak oxygen consumptions are the most often reported measures of CRF.

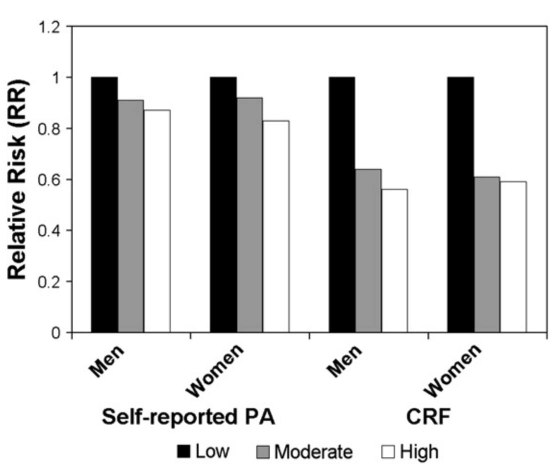

Fig 1. Relative risk of CVD mortality in 31,818 men (1492 deaths; average follow-up, 14.6 years) and 10,555 women (230 deaths; average follow-up, 12.8 years). Self-reported PA substantially underestimates the true cardioprotective effect.[54]

Survival and the evolution of the human CV system

The environmental demands of survival

Homo sapiens evolved in an environment in which survival necessitated significant amounts of physical exertion. Consequently, human CV physiology evolved to meet the demands of that milieu. It was not only an opposable thumb that elevated early humans above other animals but also the unique capacity to expend vast amounts of energy in sustained PA.[1,7] The ability to stalk prey (ie, "persistence hunting") and gather resources over vast distances required a CV system capable of delivering atmospheric oxygen to the working musculature over an enormous range of environmental conditions. Extremes of temperature, altitude, terrain, and other environmental features regularly challenged the physiology of evolving humans.

Humans can maintain top speeds averaging more than 6.0 m/s[8] and can easily cover 10 to 50 km/d. For example, a marathon is just over 42 km (26.2 miles) and is easily traversed by tens of thousand of individuals each year.[9,10] The ability to traverse large distances is a feat that no other primate and few other mammals can perform. Nevertheless, the energetic cost of locomotion for humans is much greater than for most other animals[1] and demands twice the metabolic cost per mile traveled as similar-sized mammals.[11,12] As a result, these environmental demands obligated the adaptation of a CV and musculoskeletal capable of prodigious feats of physical exertion. Over millions of years, these adaptations as well as alterations of the social and natural environment allowed humans to become the dominant species on earth.

The social environment and energy demands of survival

The evolution of human society is inversely related to human energy expenditure[13] and the concomitant demands on the CV and musculoskeletal systems. Although a lone human is remarkably unprepared to survive in the wild, a social milieu obviates much of the physical burden of survival.[13,14] Early social hierarchies allowed for the avoidance of predators and the sharing of hunting and gathering of food. By 7000 BCE, the development of agriculture facilitated the transition from foraging and persistence hunting to a less energetically costly way of life.[15] This period, known as the "Neolithic Revolution" facilitated the ascendancy of *H sapiens* to the top of the food chain.[16] Attendant with this increasing dominance was a dramatic reduction in the energy costs of survival. Nevertheless, humans still toiled long and arduously to survive. As a result, they expended enough energy through