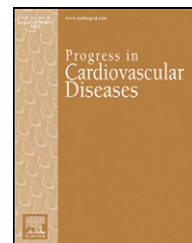


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Physical Activity and Cardiorespiratory Fitness as Major Markers of Cardiovascular Risk: Their Independent and Interwoven Importance to Health Status

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ARTICLE INFO

Keywords:

Physical activity
Cardiorespiratory fitness
Cardiovascular risk
Obesity
Diabetes

ABSTRACT

The evolution from hunting and gathering to agriculture, followed by industrialization, has had a profound effect on human physical activity (PA) patterns. Current PA patterns are undoubtedly the lowest they have been in human history, with particularly marked declines in recent generations, and future projections indicate further declines around the globe. Non-communicable health problems that afflict current societies are fundamentally attributable to the fact that PA patterns are markedly different than those for which humans were genetically adapted. The advent of modern statistics and epidemiological methods has made it possible to quantify the independent effects of cardiorespiratory fitness (CRF) and PA on health outcomes. Based on more than five decades of epidemiological studies, it is now widely accepted that higher PA patterns and levels of CRF are associated with better health outcomes. This review will discuss the evidence supporting the premise that PA and CRF are independent risk factors for cardiovascular disease (CVD) as well as the interplay between both PA and CRF and other CVD risk factors. A particular focus will be given to the interplay between CRF, metabolic risk and obesity.

Published by Elsevier Inc.

Statement of Conflict of Interest: see page 312.

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<http://dx.doi.org/10.1016/j.pcad.2014.09.011>
0033-0620/Published by Elsevier Inc.

Introduction

Evolution of physical inactivity and low cardiorespiratory fitness (CRF) as cardiovascular disease (CVD) risk factors

The evolution from hunting and gathering to agriculture, followed by industrialization, has had a profound effect on human physical activity (PA) patterns. Beginning with primitive civilizations, in which large amounts of energy expenditure were required to

Abbreviations and Acronyms

ACSM = American College of Sports Medicine
AHA = American Heart Association
BMI = body mass index
CDC = Centers for Disease Control
CHD = coronary heart disease
CT = computed tomography
CRF = cardiorespiratory fitness
CVD = cardiovascular disease
EPIC = European Prospective Investigation into Cancer and Nutrition
HF = heart failure
HTN = hypertension
MET = metabolic equivalent
MESA = Multi-ethnic Study of Atherosclerosis
MI = myocardial infarction
NHS = Nurse's Health Study
PA = physical activity
PF = physical fitness
US = United States
VO ₂ = oxygen consumption
WHR = waist-to-hip circumference ratio
WISE = Women's Ischemic Syndrome Evaluation

survive in the natural environment, human energy expenditure has progressively declined. Current PA patterns are undeniably the lowest they have been in human history, with particularly marked declines in recent generations and future projections indicate further declines around the globe.^{1–4} This is attributable to trends in automation and transportation, other social and environmental changes, and increased screen time (computers, television, etc.). Non-communicable health problems that afflict current societies are undeniably attributable to the fact that PA patterns are markedly different than those for which humans were genetically adapted.^{1–4}

Recognition of the association between PA, health, and longevity is probably as old as there are historical records. The writings of the classic Greek physicians Herodotus, Hip-

ocrates, and Galen are replete with references to fitness; each believed that a healthy body was a prerequisite for mental well-being.⁵ They recommended moderate PA to promote health, but also advised that excessive exertion may have detrimental effects on health. In the early 18th century the Italian physician Bernardino Ramazzini, considered the father of occupational medicine,⁶ compared diseases that afflicted various occupations. He noted that professional messengers, most of whom were exceptional runners, avoided the health hazards common to more sedentary occupations such as tailors and cobblers.⁷ He stated, “Let tailors be advised to take physical exercise at any rate on holidays. Let them make the best use they can of some one day, and so to counteract the harm done by many days of sedentary life”. The United States (US) founding fathers were also conscious of the importance of physical fitness (PF). Benjamin Franklin advocated 15 minutes of brisk stair climbing at intervals throughout the day, along with swimming and the use of dumbbells for health purposes.⁸ Thomas Jefferson recognized the need for activity when he wrote, “Not less than 2 hours a day should be devoted to exercise and the weather shall be little regarded. If the body is

feeble, the mind will not be strong.”⁹ The perspectives from these historical figures, stressing the importance of what we now refer to as PA and CRF, have all proven to be true.

The advent of modern statistics and epidemiological methods has made it possible to quantify the independent effects of CRF and PA on health outcomes. Based on more than five decades of epidemiological studies, it is now widely accepted that higher PA patterns and levels of CRF are associated with better health outcomes. The genesis of modern epidemiology in the context of PA is commonly attributed to Professor Jeremy Morris and his colleagues¹⁰ in the mid-20th century. In a series of studies, they used modern quantitative analyses, including consideration of biases due to selection and other potential confounding variables, to demonstrate that regular PA offers protection against the development of CVD. Their early work included the observation that drivers of double-decker buses in London experienced roughly twice the CVD mortality than the comparatively more physically active bus conductors.¹¹ Further studies among British civil servants demonstrated that physically active postal service workers appeared to be protected against CVD when compared to less active clerks, telephone operators and other government workers. These studies further suggested that when CVD did develop among those in more active occupations, it developed at later ages and was less severe. These findings were confirmed and extended by others, most notably Paffenbarger and colleagues,^{12–14} initially among San Francisco longshoremen and later among Harvard Alumni. Dr. Paffenbarger's work more precisely identified the amounts and types of PA that were associated with longevity, along with the risks associated with being chronically inactive.

In 1956, President Eisenhower established the President's Council on Youth Fitness, a result of the growing concern for the lack of PF among American youth. The Council on Youth Fitness was specifically a response to the perception that many young men were unfit for military duty, and that poor PF was attributable to dramatic changes mechanization and thus the nature of work and recreation. A month after his inauguration in 1961, John F. Kennedy convened a national conference on PF. With the cooperation of 19 US educational and medical organizations, the president's council initiated a school curriculum with the goal of improving PF, including a minimum amount of time devoted to vigorous PA daily. For much of the mid-twentieth century, the focus of these efforts was on youth PF, but an appreciation for the health consequences of physical inactivity in adults was evolving through epidemiologic studies. In 1961, Kraus and Raab¹⁵ published the text *Hypokinetic Disease*, which many consider to be a landmark publication linking many chronic conditions to physical inactivity. Health problems associated with sedentary lifestyles became a focus of study by numerous medical and research communities. In the 1970s, the American College of Sports Medicine (ACSM) Guidelines for Exercise Testing and Prescription were first published, and the 8 subsequent editions of this text have provided evidence-based and widely-applied recommendations on the volume, duration, and intensity of exercise to promote health.¹⁶

During the last two decades, a wealth of epidemiologic studies has documented the health benefits of regular PA. It is now widely appreciated that higher CRF and PA patterns are beneficial for the prevention of not only CVD, but also site-

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