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Exercising for Health and Longevity vs Peak Performance: Different Regimens for Different Goals

Everything in excess is opposed to nature.
Hippocrates[1]

Accumulating evidence suggests that exercise practices that are ideal for promoting health and longevity may differ from the high-volume, high-intensity endurance training programs used for developing peak cardiac performance and superb cardiorespiratory fitness (CRF). Studies consistently show that regular moderate-intensity physical activity (PA) is highly beneficial for long-term cardiovascular (CV) health.[2-4] Improving the CRF from low to moderate to high will progressively improve CV prognosis and overall survival.[5] However, the survival benefits from improvements in the CRF plateau at about 10 metabolic equivalents (with 1 metabolic equivalent equal to an oxygen consumption of 3.5 mL O_2/kg body weight per minute), with no additional survival benefit accruing from higher CRF levels.[5-7] Clearly, 30 minutes of regular vigorous PA enhances health and well-being, but performing 3-hour bouts of strenuous PA does not multiply the health benefits. Indeed, recent studies suggest that extreme exercise may evoke acute elevations in cardiac troponin I and B-type natriuretic peptide and evidence of transient myocardial dysfunction.[8,9]

"Cardiac overuse injury" is the term we have suggested for this increasingly common consequence of the "more exercise is better" strategy.[4,10] Many seasoned endurance athletes have experience with orthopedic overuse injuries such as plantar fasciitis, Achilles tendonitis, shin splints, and patellar chondromalacia. However, cardiac overuse injury may be associated with more ominous outcomes, including threatening cardiac arrhythmias, accelerated coronary plaque formation, premature aging of the heart, myocardial fibrosis, plaque rupture and acute coronary thrombosis, and even sudden cardiac death.[11]

See also pages 1187 and 1195

Exercise and Survival: The Reverse J-Curve Pattern

Williams and Thompson,[2] reporting in the current issue of the *Mayo Clinic Proceedings*, used the National Walkers' and Runners' Health Studies database, through which they followed 2377 survivors of myocardial infarction to assess the dose-response relation between exercise and CV disease—related mortality during long-term follow-up. Chronic running or walking was associated with progressively lower CV mortality risks up to a point, beyond which much of the benefit of exercise on CV longevity was lost (in a reverse J-curve pattern). Remarkable dose-dependent reductions of up to 65% in CV mortality were seen among cohorts who were running less than 30 miles (50 km) per week, or walking less than 46 miles (75 km) per week. Of interest, this study confirmed previous reports showing that the CV benefits of walking and running were equivalent as long as the energy expenditures were the same (though when walking, as compared to running, it will take about twice as long to burn the same number of calories).

Very recently, a similar reverse J-curve pattern was described in a German cohort study of 1038 individuals with stable coronary heart disease (CHD).[3] The 2 major findings that emerged from their data set were the same as

those reported by Williams and Thompson[2]: (1) physically inactive individuals were at the highest risk for adverse health outcomes and (2) the most physically active group (those doing strenuous PA on a daily basis) was at an increased risk of CV mortality compared with moderately active individuals. During this 10-year study, the most sedentary group was at 2-fold increased risk for myocardial infarction or stroke and 4-fold increased risk of death compared with the moderately active group. However, the individuals who performed strenuous exercise on a daily basis were also about twice as likely to die of myocardial infarction or stroke compared with the moderately active individuals.[3]

Epidemiological studies focusing on healthy populations have reported similar reverse J-curve or U-curve patterns for exercise and long-term outcomes.[10-12] Moderate exercise, as compared with physical inactivity, markedly reduces the risk of both CV and all-cause mortality.[10-12] However, at the more extreme levels of chronic endurance exercise (generally high-mileage running), there is the potential for a plateau or even a decline in benefit, with heightened risks for both musculoskeletal and CV complications. A very recent study of more than 55,000 individuals, including more than 13,000 runners, followed for more than 15 years, found that runners compared with nonrunners had reductions in all-cause mortality and CV mortality by 30% and 45%, respectively, though slight reverse J-shaped curves were again apparent.[13] The maximal benefits were noted at moderate mileage and moderate speeds, and exercise frequencies of fewer than 6 d/wk.[13] Collectively, the data suggest that moderate doses of exercise are sufficient for conferring optimal CV and longevity benefits and very high doses of PA appear to offer little or no additional survival benefit.[14] The hypothetical upper dose limit for safe exercise remains unclear, but generally keeping the intensity, frequency, and duration of exercise all in the moderate ranges may be important for maximizing health and longevity benefits.[10-13,15-17]

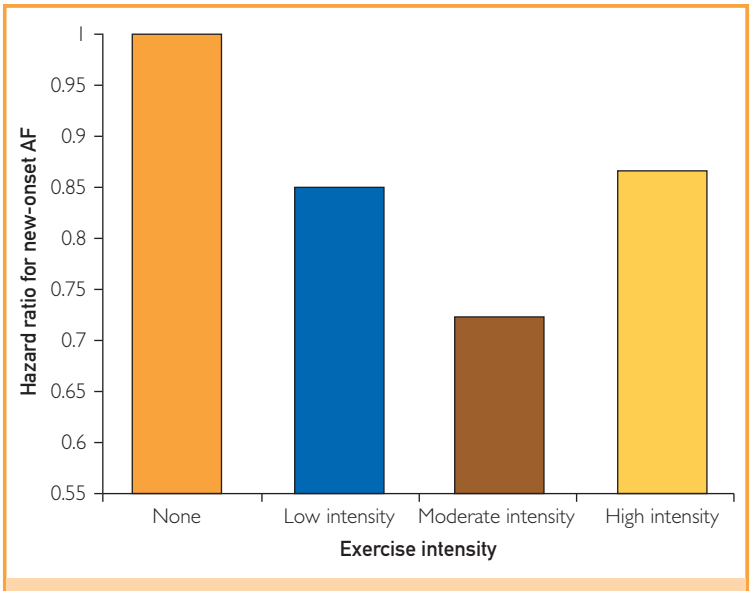

FIGURE 1. Risk of new-onset atrial fibrillation among 5446 older adults (>65 years) as a function of exercise intensity.[21]

Exercise and Atrial Fibrillation

Many epidemiological and observational studies have reported a strong statistically significant association between chronic high-intensity aerobic exercise and a heightened risk of developing atrial fibrillation (AF).[18-21] The impact of habitual PA on the risk of AF, like the risk of mortality, appears to also be nonlinear. Compared with sedentary individuals, lower rates of AF have been noted among the moderately active, whereas higher rates are seen among individuals performing excessive amounts of vigorous, high-intensity exercise in the long term.[20,21]

A recent, large study used a population-based cohort design to evaluate the link between PA and the risk of AF among 44,410 Swedish men.[20] The authors found that intense exercise of more than 5 h/wk at age 30 years increased the risk of developing AF later in life. In contrast, moderate-intensity PA, such as walking or bicycling, in middle age decreased the risk of AF.[20] Similarly, a prospective observational study of older men and women (mean age 73 years) reported that moderate-intensity PA such as walking reduced the risk for AF by about one-third.[21] Still, exercise intensity in that study showed the familiar reverse J-shaped relationship with the risk of AF (Figure 1). Another large cohort study, this one evaluating 52,755 long-distance cross-country skiers competing in an annual 90-km race in Sweden, found higher rates of arrhythmias including AF among the men and women who had the (1) greatest number of completed cross-country races and (2) fastest finishing times.[18] Fortunately, much of the risk for AF

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seems to resolve with detraining and moderation of the exercise dose, probably in part because of the normalization of the autonomic tone.[22]

Health Dividends from Sports Stardom

Also in this issue of the *Mayo Clinic Proceedings*, Garatachea et al[23] present a meta-analysis of long-term health outcomes in former top-level athletes, noting that they tend to live longer than the general population and have lower mortality rates for both CV disease and cancer. Thus, they conclude that previous intense exercise does not seem to adversely affect longevity. However, the analysis was plagued by numerous methodological limitations. For example, the studies they analyzed included athletes from varied sports ranging from professional baseball and the National Football League (American football) to soccer, cycling, and certain Olympic events. Many of these sports do not involve sustained intense aerobic efforts, which is the specific pattern of exercise that has raised concerns about cardiac overuse injury. Second, professional athletes are typically in their 20s when the somatic and CV systems are most resilient to stresses induced by intense exercise. Most of these athletes probably markedly reduced their PA levels when they retired from their sport. Third, top-level athletes tend to be physically gifted, health-conscious individuals who tend to enjoy exercise and understand the importance of healthy diet and the avoidance of tobacco smoking, all of which promote longevity. Finally, society bestows on professional athletes and Olympic heroes high socioeconomic status, which is strongly associated with better health and superior longevity. Indeed, winners of a Nobel Prize or an Oscar Award have also been shown to have superior life expectancy as compared with the general population.[24,25] Although the study by Garatachea et al[23] cannot be used to completely exonerate chronic extreme endurance exercise, it at least reassures us that previous high-level physical exertion among young elite athletes does not seem to adversely affect their life expectancy.

Marathon Running and CHD

The number of Americans participating in marathons has increased 25-fold over the past 40 years.[4] Despite the favorable risk factor profiles and extraordinary CRF of long-distance runners, race-related cardiac fatalities in marathon runners are reported each year.[26] In addition, the running study by Lee et al[13] discussed above found that higher running doses were associated with higher levels of CRF, but this did not translate into better CV or all-cause survival (which peaked at low-dose exercise). Paradoxically, long-term marathon running has in some studies been associated with increased, not decreased, coronary plaque development. Schwartz et al[27] found by using coronary angiography that compared with sedentary, age-matched controls, veteran male endurance runners (who had run at least 1 marathon each year for 25 consecutive years) had significantly increased amounts of coronary plaque, both hard and soft (Figure 2).

Using CV magnetic resonance imaging, Trivax et al[8] reported that marathon running causes acute dilation of the right atrium and the right ventricle, reduction in the right ventricular ejection fraction, and elevations in cardiac troponin I and B-type natriuretic peptide—possible harbingers of adverse long-term CV sequelae, including fibrosis. About 50% of the runners will have an abnormally elevated troponin level after a marathon; these individuals are more likely to have myocardial fibrosis than do marathoners

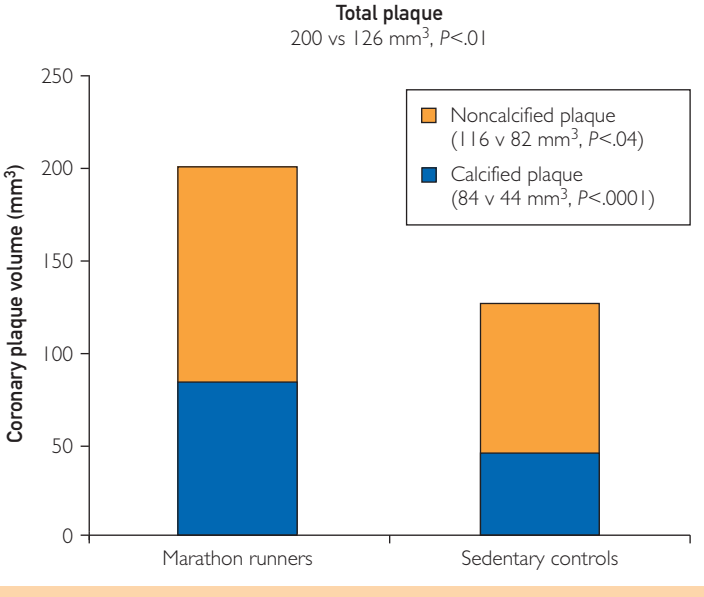

FIGURE 2. Male marathoners had significantly more total coronary plaque volume, noncalcified plaque volume, and calcified plaque volume than did sedentary controls.[27]

with normal postrace troponin levels.[9] Moreover, in this study, higher coronary artery calcium scores and myocardial fibrosis were associated with higher CHD event rates during follow-up.[9]

Optimal Dosing of Exercise

From a population-wide perspective, physical inactivity is a much more prevalent public health problem than excessive exercise. The *Physical Activity Guidelines for Americans* call for 150 min/wk or more of moderate-intensity aerobic PA or 75 min/wk of vigorous-intensity aerobic PA.[28] A recent survey of a half million adults in the United States reported that about 10 of every 20 people fail to obtain this suggested minimum weekly dose of PA.[28] However, extrapolation of the data from the current Williams and Thompson[2] study to the general population would suggest that approximately 1 of 20 people is overdoing exercise, potentially increasing the risk-to-benefit ratio. Individuals from either end of the exercise spectrum (sedentary people and overexercisers) would probably reap long-term health benefits by changing their PA levels to be in the moderate range.

Exercise is unparalleled for its ability to improve CV health, quality of life, and overall longevity. If the current mantra "exercise is medicine" is embraced, PA might be best analogized as a drug, with indications and contraindications, as well as issues related to underdosing and overdosing. As with any powerful therapy, establishing the safe and effective dose range is fundamentally important—an insufficiently low dose may not bestow full benefits, whereas an overdose may produce dangerous adverse effects that outweigh its benefits. Fortunately, the exercise dose-response range that is safe and effective for improving CV health and longevity is broad. Although there is a concerted, research-based effort to reduce physical inactivity and prolonged periods of sitting, increasing data regarding the other end of the exercise continuum now suggest that it may be possible to have too much of a good thing.[15]

On the basis of multiple studies, it might be prudent to limit chronic vigorous exercise to no more than about 60 min/d.[2-4,13,20] This recommendation is reinforced by a trial of 60 men with stable CHD who were randomized to vigorous exercise sessions lasting either 30 or 60 minutes.[29] The 30-minute exercise bouts enhanced arterial elasticity and generated minimal oxidant stress. In contrast, the 60-minute sessions amplified oxidant stress and transiently stiffened blood vessels, especially among men older than 50 years.[29]

A weekly cumulative dose of vigorous exercise of not more than about 5 hours has been identified in several studies to be the safe upper range for long-term CV health and life expectancy.[2-4,10-13,20,29] It may also be beneficial to take 1 or 2 days a week off from vigorous exercise and to refrain from high-intensity exercise on a daily basis.[2-4,10-13,20]

"If we could give every individual the right amount of nourishment and exercise, not too little and not too much, we would have found the safest way to health,"[1] Hippocrates stated more than 2000 years ago, and we believe this assessment continues to provide wise guidance.

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