The risks and benefits of exercise: do we have a finite number of heartbeats?

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The risks and benefits of exercise will be reviewed. Exercise does appear to prolong life in those who exercise regularly. Unfortunately exercise may trigger acute ischemic events and sudden cardiac death. The physiologic effects of acute and chronic exercise will be examined particularly as these relate to cardiovascular testing in endurance athletes.

Paffenbarger et al. evaluated over 10 000 Harvard alumni comparing overall mortality with physical activity. There was a clear-cut stepwise decrease in mortality with increase in expenditures of energy, as measured by kilocalories per week. Those who were previous athletes and stopped exercising were at the highest risk. Lifelong athletes have the lowest risk, but were followed closely by those who assumed an active lifestyle in later years. Sandvik et al. similarly evaluated nearly 2000 Norwegian middle-aged men with baseline tests assessing fitness with long-term follow-up. There was a graded inverse association between quartiles of fitness and mortality, as well as with risk factors such as blood pressure and total cholesterol. Ekelund et al. evaluated over 4000 middle-aged men, and demonstrated an inverse relationship between quartiles of fitness based on an exercise stress test and not only mortality but cardiovascular-related mortality. Lakka et al., following over 1400 middle-aged men for nearly 5 years, demonstrated an inverse correlation between hours of conditioning per week as well as maximal oxygen consumption and relative hazard of death. The only large-scale observational study including women was performed by Blair et al.: 25 000 men and over 7000 women underwent examination and exercise stress test with subsequent long-term follow-up. Low fitness was a significant relative risk factor for both populations (male and female), and carries a higher relative risk of death than smoking, hypertension, or hypercholesterolemia in women. These data have been so overwhelming that the NIH Consensus Conference agreed that children and adults should set a goal of accumulating at least 30 min of moderate intensity physical activity on most, and preferably, all days of the week .

As Pheidippides demonstrated, there are risks of death with exercise. Thompson et al. have calculated that there is a 7-fold increase in the risk of death during jogging compared with sedentary controls. Analysis of those reported to have died suddenly while jogging reveals that approximately half had a history of cardiovascular disease or prodromal symptoms. In addition, most of those affected had significant risk factors including continued tobacco abuse, hypercholesterolemia, prior confirmed myocardial infarction, or a prior family history of early cardiovascular disease. Mittleman et al. demonstrated that physical exertion can clearly trigger myocardial infarction. The risk appears to be increased in individuals who are sedentary and decreases with habitual physical activity. It is assumed that exercise likely triggers acute plaque rupture due to underlying coronary atherosclerosis and the hemodynamic burden of increased physical activity.

Acute exercise increases venous return due to intrathoracic pressure and increased muscular contraction (milking of dependent veins). Left ventricular volume increases as does cardiac output due to the Starling effect. Sympathetic tone also increases, which increases contractility and lusitropy. Chronic exercise increases muscle capillary beds, muscle enzyme activity, left ventricular vol-

ume, and left ventricular wall thickness. Deconditioning can occur within 2-3 weeks of discontinuation of exercise. Pelliccia et al. have shown that a left ventricular wall thickness in excess of 13 mm is very uncommon, even in highly trained competitive endurance athletes. Endurance training does have a dramatic effect on the electrocardiogram. Virtually all trained athletes have intrinsic bradycardia and an increased propensity to sinus arrhythmia, first degree heart block, and sinus pauses. In addition, left ventricular hypertrophy is common, right ventricular hypertrophy not uncommon, and early repolarization found in nearly 50%. ST segment changes are not found, even in endurance athletes.

In addition to lowering blood pressure, exercise has beneficial effects on other cardiovascular risk factors. Williams has demonstrated in women and men endurance runners that there is an inverse correlation between HDL and distance run per week. Endurance athletes have lower total cholesterol, triglycerides, LDL and VLDL and significantly higher HDL. In addition to lower levels of cholesterol, there appears to be an increase in reverse cholesterol transport from cells in athletes. This would further lower the cellular cholesterol levels. Exercise does, however, appear to increase the platelet count and, potentially, the platelet adhesiveness. Fibrinolysis is increased.

There is evidence in animals and humans that exercise increases the capability for coronary vasodilation. In animal models this appears to be due to an enhanced nitric oxide-dependent vasodilation, likely due to increases in nitric oxide production and synthase.

There is a multitude of proposed psychological benefits of exercise, likely enhanced by beta endomorphines. Unfortunately, there are relatively few controlled trials proving these benefits. There is also proposed psychological harm from exercise including compulsiveness, chronic fatigue, over-competitiveness, and self-centeredness.

In brief, exercise clearly prolongs life. There are risks related to exercise, particularly in those who have been habitually sedentary. In this population, exercise must be undertaken gradually and if significant risk factors are present, individuals should undergo cardiovascular screening including an exercise stress test before initiating a vigorous program. Highly-trained endurance athletes have abnormalities of their noninvasive cardiac parameters including electrocardiogram, Holter and echocardiogram. Chronic exercise clearly improves multiple risk factors for cardiovascular mortality including weight, blood pressure, insulin sensitivity, thrombosis, and lipid levels.

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