Accelerated Decline of Aerobic Fitness With Healthy Aging

What Is the Good News?

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As we get older, even if we are healthy, we become less fit. At the extreme, we become disabled and eventually die. Although this deterioration in physical work capacity is widely accepted, few studies have characterized changes in aerobic capacity across the age span. Instead, the majority of studies have utilized cross-sectional designs. These studies are limited, however, by selective survival—ie, older participants, as a group, are inherently healthier than younger individuals, as evidenced by their survival. Thus, the 5% to 10% drop in aerobic fitness per decade, defined from cross-sectional studies, may well be an underestimate.1–6

The Baltimore Longitudinal Study of Aging

The Baltimore Longitudinal Study of Aging began recruiting healthy individuals into a long-term descriptive study in 1978.7 Subjects were screened at baseline for clinical heart disease. Screening included a symptom-limited exercise test supplemented by nuclear perfusion imaging in men >40 and women >50 years of age. The participants were predominantly white and college educated and lived in the Baltimore-Washington metropolitan area. Every 2 years they spent 2 full days at the Gerontology Research Center in Baltimore, Md, where they underwent medical, physiological, and psychological testing. Individuals without onset of clinical heart disease underwent maximal treadmill exercise testing on alternate visits. It should be noted that although elimination of individuals who developed clinical heart disease allowed the researchers to examine the effects of aging per se on exercise capacity without the confounding effects of disease, this approach almost certainly removed less-fit individuals from the analysis because poor fitness is a well-known cardiac risk factor. A total of 3379 exercise tests were performed in this study, all consistently supervised by the same cardiologist (Dr Fleg). Another 10% of tests were excluded because of failure to attain 85% of the maximal predicted heart rate or because the tester deemed a test to be nonmaximal on the basis of direct observation. Finally, another 3% were excluded for individuals who were taking a β-adrenergic–blocking medication. One could question whether the individuals with chronotropic incompetence or inability to attain 85% of the maximal age-predicted heart rate should have been excluded if they otherwise performed a maximal test, verified by the attainment of a respiratory exchange ratio >1.00, as these simply may have reflected the tail of the bell-shaped maximal heart rate curve. It is possible that this factor, again, excluded the least fit individuals.

The resulting dataset represents the most comprehensive examination of longitudinal changes in aerobic fitness throughout the aging spectrum in healthy individuals. By clustering repeated exercise test data within 6 age decades, a rate of decline within successive decades is calculated. Thus, the selection biases inherent in cross-sectional studies—in particular, the fact that older participants, by dint of their survival, are generally healthier than younger participants overall—are avoided. Fleg and coworkers7 show that the previously defined linear decline of aerobic capacity of 5% to 10% per decade is indeed incorrect, particularly in the later decades of life. Most importantly, these data suggest that the age-related decrease in aerobic capacity is nonlinear, increasing progressively each decade. For example, whereas the decline in peak VO2 was 3% to 6% in the third and fourth decades, it was far greater, >20% per decade, after age 70. The accelerated decline persisted even when the data were adjusted by fat-free mass, which also declines with age. Although it is possible that the effect of fat-free mass on peak VO2 was not entirely corrected for by calculating a simple ratio of peak VO2 (mL/min) divided by fat-free mass,8 it is unlikely that loss of muscle mass alone accounts for the accelerated decline in fitness given the pattern of age-related changes in fat-free mass. Reduced peak VO2 was found in all physical activity quartiles. It should not be overlooked, however, that more physically active individuals had higher peak VO2 measures than less active individuals at all ages.

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Instead, changes that alter the delivery of oxygen to exercising muscles or the ability of muscles to utilize oxygen are more likely determinants of declining aerobic fitness. If this is the case, age-related changes in muscle perfusion or oxidative capacity may lie at the root of diminished aerobic exercise capacity in the elderly. In support of an effect of age on muscle oxidative capacity, recent findings show that aging is associated with impaired skeletal muscle mitochondrial function secondary to mitochondrial DNA oxidative damage and loss.9

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Age: Bad News?

Because the logical end point of declining exercise capacity, at its extreme, is death, one can question whether these data...
are also relevant to overall mortality. Similarly, one can also question if, as Fleg et al suggest, the presented data are relevant to an accelerated development of functional disability. Do individuals have no ability to alter structure, function, or clinical outcome by exercise or other lifestyle habits? Should all who pass the age of 40 passively resign themselves to a fast track to physical disability?

With regard to the implications of these data on mortality, I am reminded of the treatise of baseball statistician Bill James relating the peak of a player’s hitting ability to the length of his career in the Major Leagues. The higher the peak of the parabolic curve of hitting ability versus age, the broader the parabola as it crosses the x-axis (in years), the longer the stay in the Major Leagues. Although the data of Fleg et al support the concept that whatever the aerobic fitness level, whatever the physical activity level, there is a sharper decline over time after age 60 or 70 than before, they do not deny data from several sources that relate peak aerobic capacity and physical activity in middle-aged adults to increased longevity11–13 and delayed disability.14,15 Again, a higher peak yields a broader parabola with increased longevity. Furthermore, if you accept the concept that some physical dysfunction will generally precede death (absent a sudden death), it is in fact preferable for the graph of the decline to have a shelf with maintained aerobic capacity, until an accelerating late drop, as opposed to a more protracted, linear deterioration.

A separate though relatively minor concern with these fitness data from the Baltimore Longitudinal Study of Aging is that of the healthy cohort effect.16 This suggests that individuals who volunteer for health-related research studies are often more fit and health oriented than the population as a whole. In the study of Vita et al,14 several lifestyle factors, including exercise patterns, body mass index, and smoking, were closely related to end-of-life disability patterns. Not including exercise patterns, body mass index, and smoking, are also relevant to overall mortality. Similarly, one can also question if, as Fleg et al suggest, the presented data are relevant to an accelerated development of functional disability. Do individuals have no ability to alter structure, function, or clinical outcome by exercise or other lifestyle habits? Should all who pass the age of 40 passively resign themselves to a fast track to physical disability?

Fitness Versus Disability

Whether this decline in aerobic fitness leads to functional disability is not as clear as implied. Disability is a complex construct that includes not only aerobic capacity, which in practical terms is reflected by walking capacity, but also strength, balance, coordination, and psychological factors.17,18 Perhaps the best-studied biological correlate of physical function outside of aerobic fitness is muscle strength. Muscle strength has been shown to be at least as important a determinant of functional capacity as endurance in healthy and diseased elderly persons,19–21 and strength training can improve performance of walking, climbing stairs, carrying groceries, and other household activities without altering aerobic capacity. This implies that the very activity of lifting the leg while walking, a trivial detail in the young, is a limiting factor to walking endurance in the elderly. Caution should be taken, however, in imparting too much importance to biological factors alone. As much as functional capacity is limited by physiological capacity, it is undoubtedly dependent on psychological factors. For instance, recent work from our laboratory showed that mental depression was an equally important determinant of self-reported disability as was aerobic fitness in older patients with heart disease.17 These findings do not, of course, deny the findings of Fleg et al but raise the question of whether the drop in aerobic capacity translates into a proportional drop in physical functional performance. For instance, Posner et al25 showed that the ability to perform activities of daily living was not dependent on aerobic fitness until peak VO2 dropped below ~750 mL/min. Thus, although erosion of peak VO2 with age undoubtedly accompanies the development of disability, its overall contribution to the reduced capacity to perform normal daily activities is unclear.

Conclusions

The important article by Fleg and colleagues presents a comprehensive examination of longitudinal changes in aerobic fitness through the aging spectrum in healthy individuals. The foresight and energy of the investigators are laudable, as such a dataset could not have been assembled without persistence and focus. A particular strength is the collection of repeated-measures longitudinal data, which avoids the biases of cross-sectional studies. A decline in aerobic fitness was noted after age 40, which accelerates as individuals enter their sixth and seventh decades. This decline is independent of muscle mass and physical activity levels. Thus, the bad news is that your aerobic fitness will decline with age no matter what you do. The good news is that individuals who start with higher aerobic capacity and continue their activity habits throughout life maintain a greater fitness level at all points in the aging spectrum. In light of the relationship between aerobic fitness and mortality,11–13,14 this suggests that performance of regular exercise throughout the lifespan will both lengthen life and postpone and compact end-of-life disability.13,14

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References


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