Aging in Sport and Exercise

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Aging Process

Aging Refers to the normal irreversible biological changes that occur throughout a persons lifetime.

- **With advancing age, we become less able to repair damage caused by internal malfunction or external assault to the body.**
- **Various biochemical and hormone changes with ageing may finally lead to death.**
- **The immune system is less effective in the elderly.**
- **The body may be less able to combat infection or destroy abnormal body cell.**

As a person age, many changes take place in the body

- Loss of taste and smell
- Decreased in gastrointestinal function
- Loss in visual and auditory function
- Loss of bone mineral mass
- Decreased in lean body weight
- Mental impairment

Physiological Changes Accompanying the Aging Process

- Muscle size Decreased
- Muscle strength Decreased
- Percent body Fat Increased
- BMR Decreased
- Maximal heart rate Decreased
- Overall heart size Decreased
- Cardiac muscle strength Decreased
- Maximal stroke volume Decreased
- Maximal cardiac output Decreased

- **Maximal blood flow Decreased**
- **BP Increased**
- **Vo2 max Decreased**
- **Vital capacity Decreased**
- **Maximal expiratory ventilation Decreased**
- **Pulmonary diffusion capacity Decreased**
- **Reaction time Decreased**
- **Movement time Decreased**
- **Flexibility Decreased**

Aging Effects vs. Reduced Physical Activity

Since physical activity tends to decline substantially as we age, distinguishing between the effects of aging and those of reduced physical activity on physiological function is difficult, especially in cross-sectional study designs.

Aging and Muscle Loss

- **As a normal part of the aging process, individuals experience a loss of skeletal muscle. This loss of muscle has been well documented in individuals over the age of 50.**
- **This loss of muscle tissue, with an associated loss of strength and mass, is referred to as sarcopenia.**
- **Sarcopenia can be decrease in the maximal contractile strength on the order of 20-40% for both men and women is observed.**
- **The weakness associated with sarcopenia has been shown to be associated with difficulty in rising from a chair and getting out of bed.**

- **Decreases in muscle quality may also be a contributing factor in increased fracture risk in older individuals.**
- **Also associated with a decrease in muscle mass and muscle strength is a decrease in the rate of force development in the muscles of elderly individuals.**
- **Aging is associated with oxidative stress and subsequent local inflammation in skeletal muscle.**
- **Oxidative stress, by way of increased free radical generation, causes oxidative modification and damage to protein, lipid, and DNA in skeletal muscle.**
- **This invariably leads to cellular dysfunction and muscle protein degradation, as well as a decline in muscle mass and function.**

Aging Effects on Skeletal Muscle

- **Strength training remains highly effective in maintaining muscular strength throughout life.**
- **However, after about age 60, strength levels fall more rapidly, independent of training.**
- **This is probably influenced by changes in hormones such as testosterone and growth hormone, which appear to decline more dramatically after age 60.**
- **Reduction in the circulating concentration of these hormones will result in a shift in the balance between muscle protein synthesis (anabolism) and protein breakdown (catabolism).**
- **The decreased strength is due to atrophy of muscle fibers.**

Healthy Adults

	Recommendations for Aerobic Activities*	Recommendations for Resistance Exercises*
Frequency	• Perform moderate-intensity aerobic physical activity on at least 5 days per week or vigorous-intensity activity on at least 3 days per week, or a weekly combination of 3 to 5 days per week of moderate- and vigorous- intensity exercise.	• Perform resistance exercise of each muscle group on 2 to 3 days per week with at least 48 hours separating the exercise training sessions for the same muscle group.
Intensity	• A combination of moderate- and vigorous-intensity aerobic exercise is recommended.	• A load of 60 to 80% of 1 repetition maximum (1-RM) is recommended for resistance exercises.

Time	• Perform moderate-intensity aerobic exercise for at least 30 mins per day to a total of at least 150 mins per week, or vigorous-intensity exercise for at least 20 mins per day to a total of at least 75 mins per week. Performance of intermittent exercise of at least 10 mins in duration to accumulate the minimum duration recommendations above is an effective alternative to continuous exercise. • For additional and more extensive health benefits, adults should increase their aerobic physical activity to 300 mins (5 hours) a week of moderate-intensity, or 150 mins a week of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity activity. Additional health benefits are gained by engaging in physical activity beyond this amount.	• 8 to 10 resistance exercises are recommended. Each muscle group should be trained for a total of 2 to 4 sets with 8 to 12 repetitions per set and a rest interval of 2 to 3 mins in between.

Type	• Aerobic exercise should be rhythmic in nature that involves large muscle groups and best requires little skill to perform. Exercise and sports requiring skill to perform or higher level of fitness are recommended only for individuals possessing respective skill and fitness. Please see Box 5.1 for certain types of aerobic exercise that could be recommended to healthy adults.	• Concerning resistance exercises, multi-joint exercises involving more than one muscle group and targeting agonist and antagonist muscle groups are recommended, while single-joint exercises targeting major muscle groups may also be included[#]. Please see Box. 5.2 for certain types of resistance exercise that could be recommended to healthy adults.

Recommendations for Stretching Exercise

- A stretching exercise of at least 10 mins involving the major muscle tendon groups of body (i.e., neck, shoulder, upper and lower back, pelvis, hips and legs) with 4 or more repetition (with 10 to 30 seconds for a static stretch) per muscle group performed on a minimum of 2 days per week is recommended. Preferably, stretching activities are performed on all days that aerobic or muscle-strengthening activity is performed.

Box 5.1 Examples of Aerobic Exercises that could be Recommended to Healthy Adults

Exercise Requiring Little Skill to Perform

- Walking
- Hiking uphill
- Window washing
- Stairs climbing
- Jogging*
- Running*
- Rowing*
- Brisk walking
- Dancing
- Sweeping, vacuuming, mopping
- Rope-jumping
- Stepping exercise*
- Aerobic dance*
- Elliptical exercise*

Benefits of Weight Training for Older Adults

- Better control of symptoms of diabetes, arthritis, osteoporosis, back pain, and depression.
- Prevents falls due to restoration of balance.
- Improved posture and stability.
- Increased flexibility and range of motion.
- Strengthens the bones and reduces risk of fractures.
- Improves muscle strength and endurance.
- Healthy, independent, and functional life.

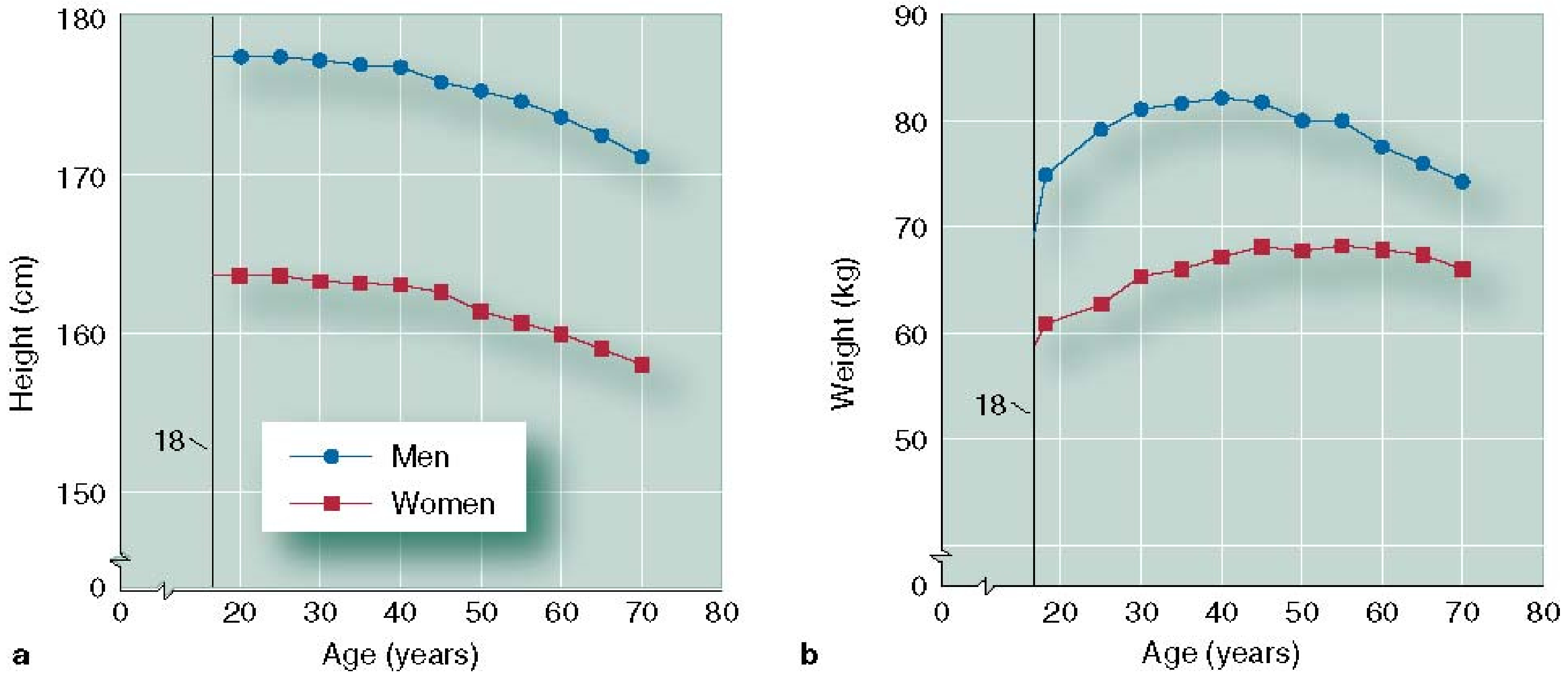
Benefits of Weight Training for Older Adults

- It is never too late to start on a muscle conditioning and weight training program.
- Weight training is especially important to slow the process of sarcopenia (age-related skeletal muscle loss).
- Regular weight training has shown to:
  - reduce blood pressure
  - improve blood cholesterol levels
  - improve insulin sensitivity
  - speed-up gastrointestinal transit
  - increase bone mineral density
  - alleviate low-back pain
  - ease arthritic discomfort
  - improve cardiovascular function
  - relieve depression
  - reduce body fat
  - improve functional abilities

Height, Weight, and Body Composition

- **Reduced height starting at ~35-40 years old**
  - **Due to compression of the intervertebral disks and poor posture**
- **Osteoporosis: severe loss of bone mass with deterioration of the microarchitecture of bone**
  - **Women age 40-50**
  - **Men age 50-60**
  - **Contributing factors include: poor diet and exercise habits throughout life, and decreased estrogen after menopause**

Changes in *(a)* Body Height and *(b)* Weight in Men and Women up to 70 Years of Age



Reprinted, by permission, from W.W. Spirduso, 1985, *Physical dimensions of aging* (Champaign, IL: Human Kinetics), 59.

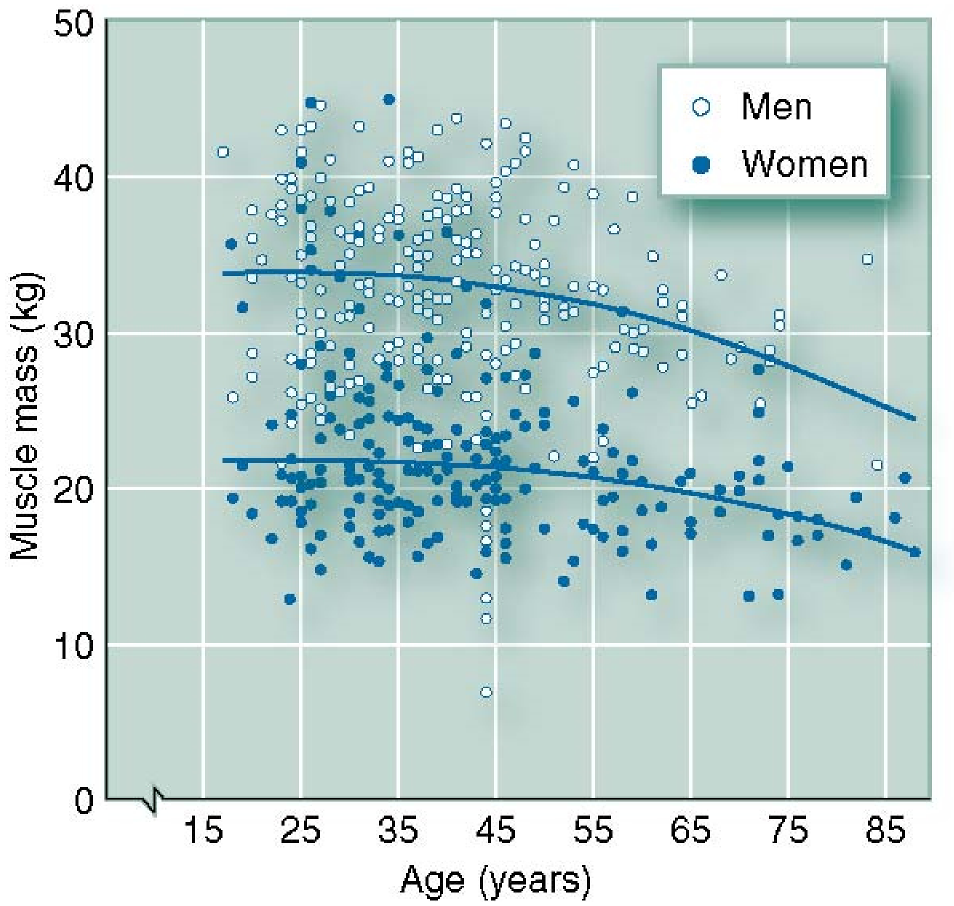
Height, Weight, and Body Composition

- Increased weight typically occurs between ages 25-45 (mainly fat) due to:
  - Decreased physical activity levels
  - Increased caloric intake
  - Reduced ability to mobilize fat stores
- Beyond age 45 weight stabilizes
- After age 65-70 weight decreases due to decreased appetite

Height, Weight, and Body Composition

- **Fat-free mass decreases progressively in both men and women beginning at ~ age 40-45**
- **Loss of muscle associated with the aging process is called *sarcopenia***
- **Muscle protein synthesis in 60- to 80-year-olds is about 30% lower than in 20-year-olds, and is associated with declines in growth hormone and insulin-like growth factor**
- **Bone mineral density decreases with age (resorption exceeds synthesis) starting at 30-35 years of age in women and 45-50 in men**

Changes in Muscle Mass With Aging



Adapted, by permission, from I. Janssen et al., 2000, "Skeletal muscle mass and distribution in 468 men and women aged 18-88 yr.," *Journal of Applied Physiology* 89: 81-88.

Height, Weight, and Body Composition

- With training, older men and women can reduce weight, percent body weight, and fat mass and increase fat-free mass
- Men appear to experience greater changes in body composition than women

Body Composition and Training

One of the important things about physical training as one ages is that it can help offset age-related loss of fat-free mass and gains in fat mass, i.e., the double whammy.

Body Composition and Aging

Key Points

- Body weight tends to increase with aging, whereas height decreases
- Body fat increases with age due to increased caloric intake, decreased physical activity, and reduced ability to mobilize fat
- Beyond age 45, fat-free mass decreases due to a decrease in muscle and bone mass—both resulting at least partly from decreased activity
- Training can help attenuate these changes in body composition, even in individuals as old as 80-90 years of age

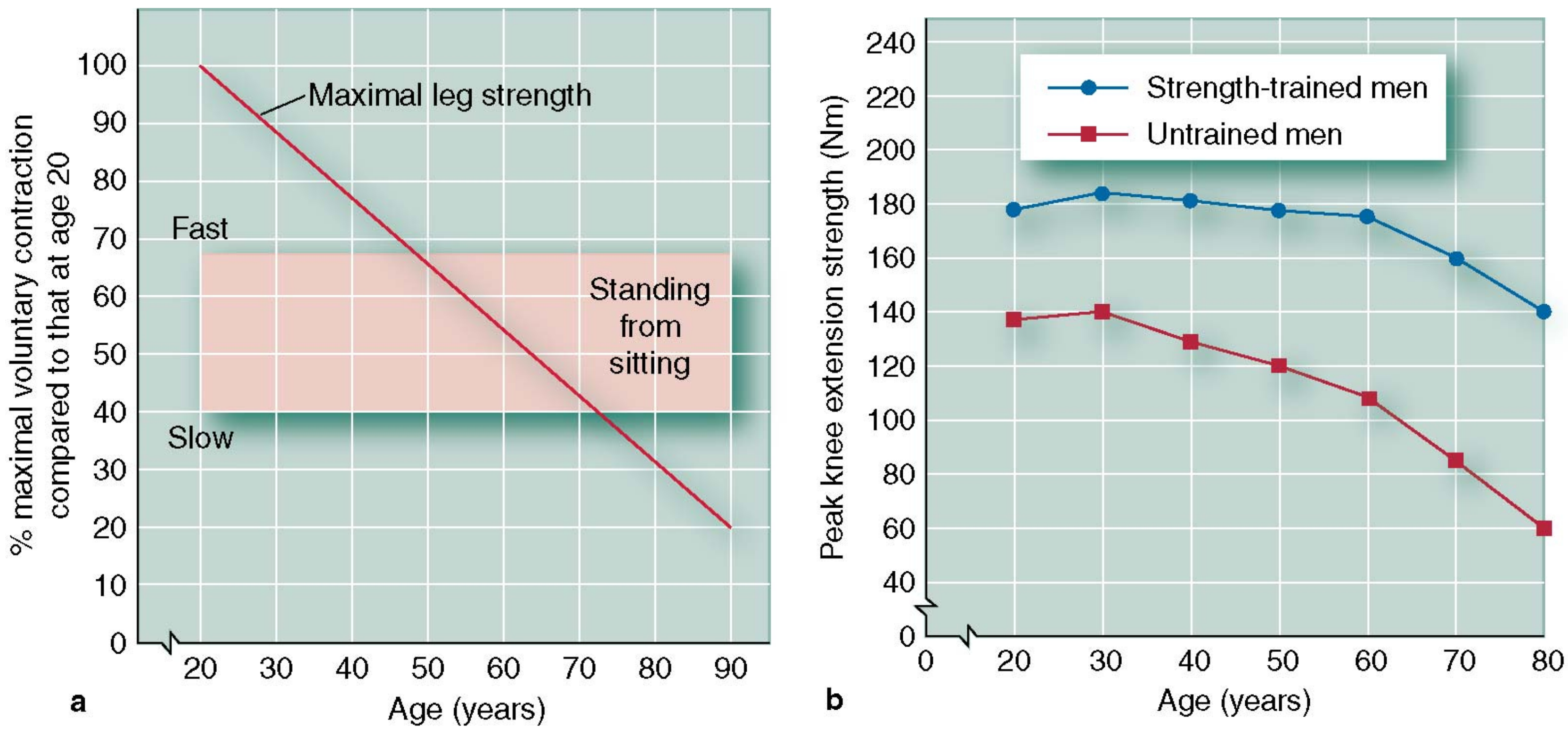
Effects of Training on Strength

While endurance training does not prevent the aging loss in muscle mass, resistance training can maintain or increase the muscle fiber cross-sectional area in older men and women.

Strength and Neuromuscular Function

- Maximal strength decreases with aging
- Declines start ~ age 40 in men and women
- Correlated with reductions in muscle cross-sectional area
- Increase in type I muscle fibers and possibly a decrease in type II muscle fibers
- Change in fiber type may be due to decreased type II α-motor neurons and/or axonal sprouting from type I α-motor neurons
- Training may attenuate the change in muscle fiber type

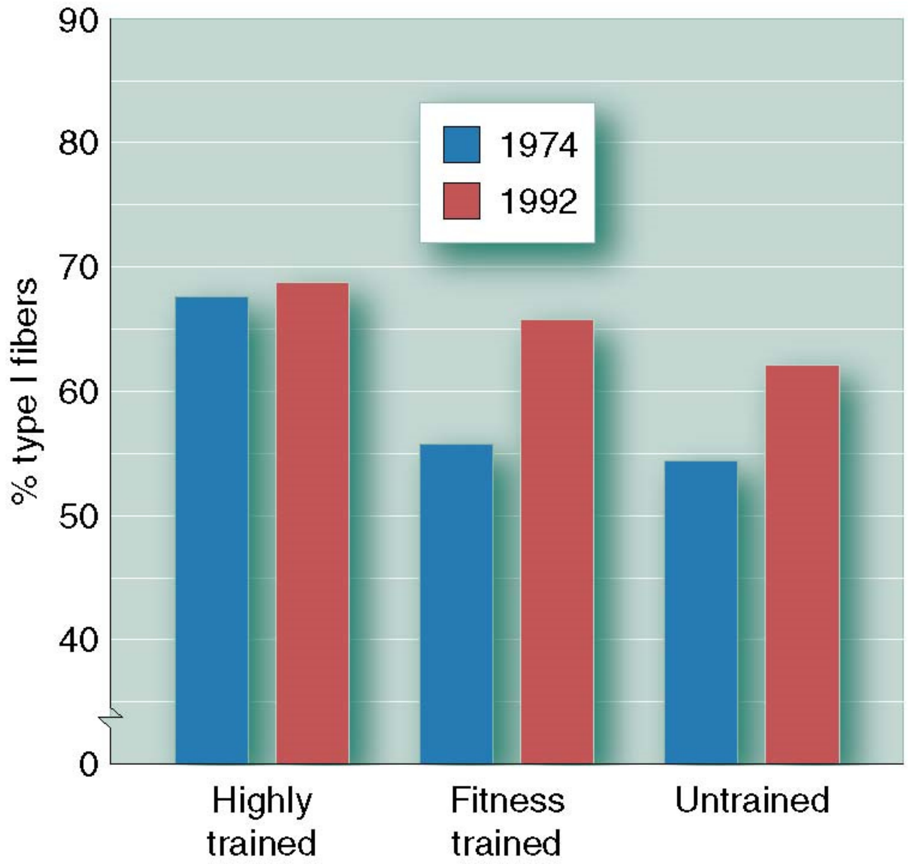
(a) Maximal Leg Strength and Speed of Standing and (b) Peak Knee Extensor Strength in Strength-Trained and Untrained Men Across the Lifespan



Strength and Neuromuscular Function

- **Motor unit activation is slower with aging**
- **Oxidative enzyme activities in muscle decline slightly (10-15%) in endurance-trained older athletes**
- **The number of capillaries per unit muscle area is similar in old and young athletes**

Changes in Muscle Fiber Type Composition in Elite Distance Runners Who Remained Highly Trained, Stayed Fitness Trained, or Became Untrained



Strength and Neuromuscular Function

Key Points

- **Maximal strength decreases steadily with aging, resulting primarily from a loss of muscle mass**
- **In general, normally active people experience a shift toward a higher percentage of type I muscle fibers as they age, possibly attributable to a reduction in type II fibers**
- **The total number of muscle fibers and the fiber cross-sectional area decrease with age, but resistance training appears to lessen the change in fiber area**

(continued)

Strength and Neuromuscular Function *(continued)*

Key Points

- Aging appears to slow the nervous system's ability to respond to a stimulus, process the information, and produce a muscular contraction
- Training cannot arrest the process of biological aging, but it can lessen the impact of aging on performance

Cardiovascular Function and Aging

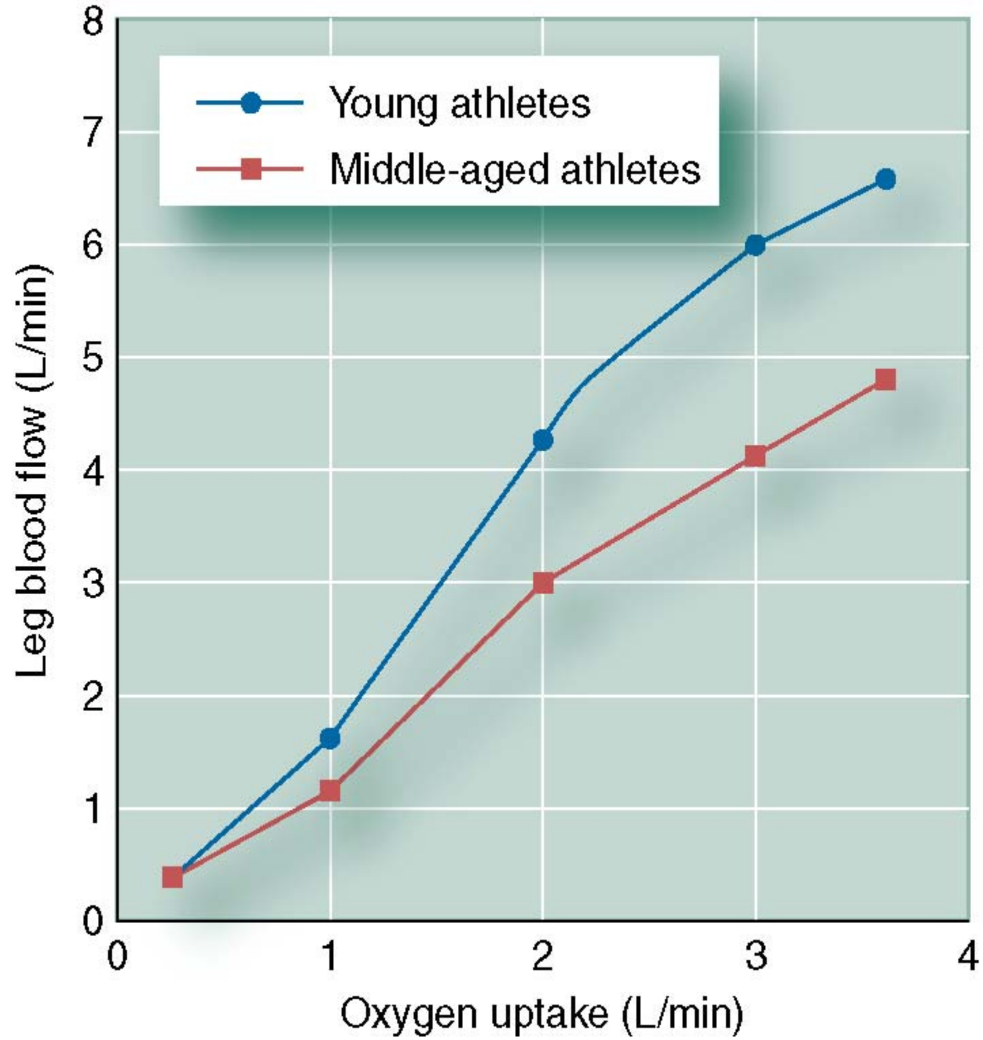
- **Aerobic capacity decreases about 1% per year after age 25**
- **Maximum heart rate decreases about 1 beat per year**
- **Maximum stroke volume decreases, though it can be well maintained with training**
- **Maximal stroke volume is fairly well maintained in highly trained older adults but is reduced in untrained men and women**
- **Muscle blood flow decreases are offset in trained individuals by an increased submaximal a-vO2 difference**
- **Decreased maximal cardiac output due primarily to a decrease in HR_{max}**

Cardiovascular Function: Peripheral Mechanisms

- Peripheral blood flow decreases
- Increase in $(\bar{a}\text{-}v)O_2$ difference in older endurance athletes
- O_2 uptake is similar in young and older endurance athletes

LEG BLOOD FLOW DURING CYCLING IN YOUNG AND MIDDLE-AGED

Thus, the older athletes maintain oxygen consumption during increasing levels of exercise by increasing a-vO2diff to a greater extent than the younger athletes.



Cardiovascular Function

Key Points

- Much of the decline in endurance performance with aging can be attributed to decreased cardiovascular function
- HR_{max} decreases ~1 beat/year as we age
- Cardiac output decreases with age because of the reduction in HR_{max}
- Stroke volume is maintained in older endurance athletes but declines in untrained people
- Peripheral blood flow decreases with age, but in trained older athletes this is offset by an increase in submaximal oxygen extraction by the working muscle

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Cardiovascular Function *(continued)*

- It is unclear how much of the decrease in cardiovascular function with aging is attributable to aging alone and how much is attributable to deconditioning
- These cardiovascular changes are attenuated in older athletes who continue to train

Respiratory Function

- **Vital capacity (VC) and forced expiratory volume in 1 sec (FEV1.0) decrease linearly with aging**
- **Residual volume (RV) increases**
- **Total lung capacity (TLC) remains constant**
- **Maximal expiratory ventilation decreases with age**
- **Change in pulmonary function is due to loss of elasticity of the lung tissue and chest wall**
- **Decreased pulmonary ventilation capacity does not decrease aerobic capacity in older athletes**

Respiratory Aging and Performance

- Endurance training in middle and older age reduces the loss of elasticity from the lungs.
- The pulmonary ventilation capabilities of endurance-trained athletes are only slightly decreased with aging.
- Arterial oxygen saturation does not decrease during strenuous exercise for normally active older adults.
- Limitations in oxygen transport to the muscles (i.e., muscle blood flow) and a decreased a-vO2 difference are the main causes for reduced VO2max.

Studies of Older Athletes

- There are individual differences in the rate of decline with aging.
- Prior training offers little advantage to endurance capacity later in life unless you stay active.
- Aging alone may not necessarily decrease VO2max; decreased daily activity levels also contribute.
- When you keep intensity and volume of training high, your rate of decrease in SV and VO2max with aging slows, especially between ages 30 and 50 and less so after age 50.

Factors Influencing the Decline in $\dot{V}O_{2max}$ With Aging

- Genetics
- General activity level
- Intensity of training
- Volume of training
- Increased body weight and body fat mass and decreased fat-free mass
- Age range, with older individuals experiencing greater declines

Aerobic and Anaerobic Function

Key Points

- Aerobic capacity generally decreases by ~1% per year in sedentary men and women
- Similar declines are observed in endurance trained older adults, but $\dot{V}O_{2max}$ will remain higher than in their sedentary counterparts
- Older athletes who continue to train have significantly smaller decreases in $\dot{V}O_{2max}$
- Lactate threshold, expressed as a percentage of $\dot{V}O_{2max}$, increases with aging, but decreases when expressed in relation to the absolute $\dot{V}O_2$ at which it occurs

Physiological Adaptations to Exercise Training

- Older adults get the same benefits from exercise training as younger and middle-aged adults
- Aging does not impair the ability to improve muscle strength or muscle hypertrophy
- Endurance exercise training produces similar absolute gains in healthy people, regardless of their age, sex, or initial level of fitness
- With endurance training, an increase in $\dot{V}O_{2max}$ in older exercisers results mostly from improvements in muscles' oxidative enzyme activities

Cardiovascular or Aerobic Activities.

Achieve the aerobic activity recommendation through one of the following options:

- **A minimum of 30 minutes of moderate-intensity physical activity per day (such as brisk walking) most days of the week.**

- **A minimum of 20 minutes of vigorous-intensity physical activity (such as jogging or running) 3 days a week**

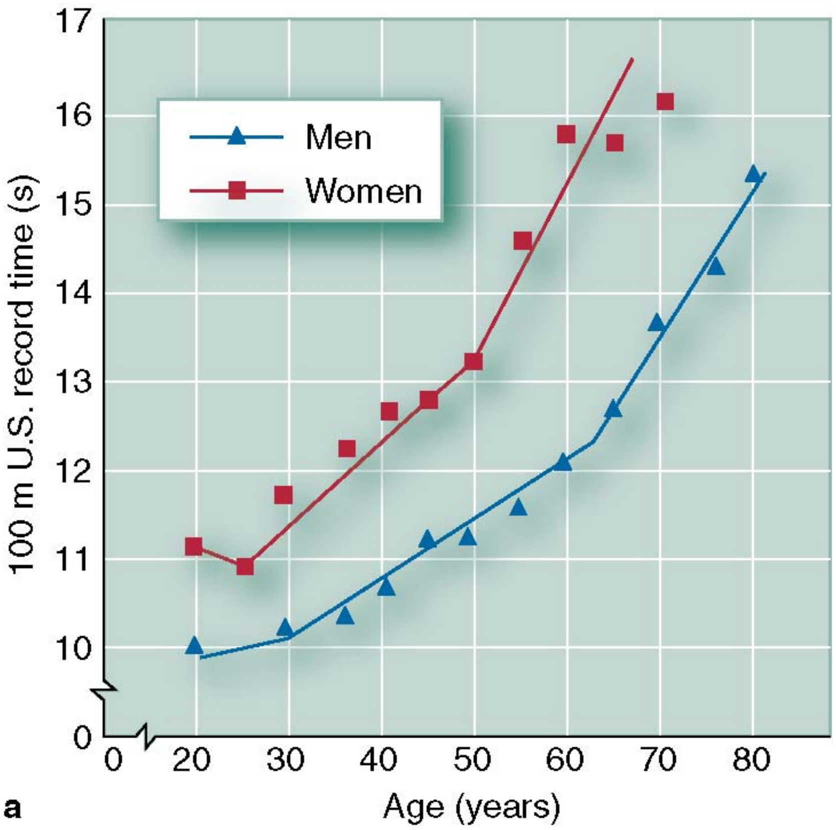
Resistance Training Activities.

- **Two days a week, incorporate strength training into your routine.**
- **Strength training activities, such as weight lifting, maintain and increase muscle strength and endurance.**
- **A goal to reach towards is completing 6-8 strength training exercises, with 8–12 repetitions per exercise.**

Sport Performance

- **Records in running, swimming, cycling, and weightlifting indicate that we are in our physical and physiological prime in our 20s and early 30s**
- **Performance generally declines with aging beyond age 30-35**
- **Most athletic performances generally declines with aging beyond our prime, primarily due to decrements in muscular and cardiovascular endurance and strength.**

Change With Age in Men's and Women's World Records for *(a)* 100 m and *(b)* 10 km Runs



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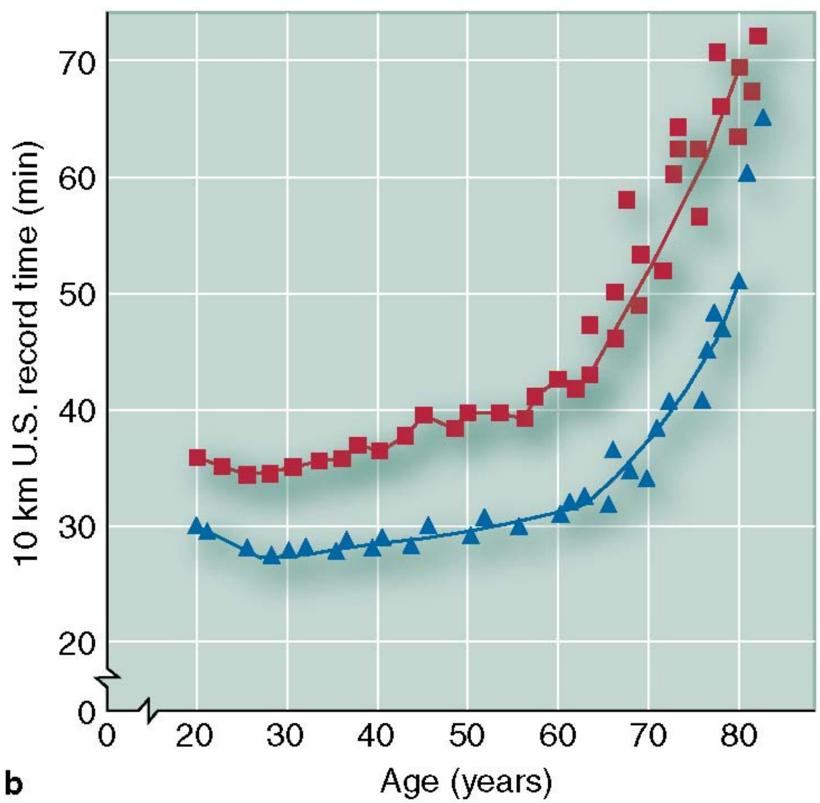

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Environmental Stress

Exposure to the Heat

- Increase in heat-related deaths over the age of 70
- Attenuated skin blood flow
- Decreased redistribution of blood flow to the skin
- Endurance training (sufficient to increase $\dot{V}O_{2max}$) can improve heat stress responses
- The impaired ability of older individuals to tolerate exercise in the heat is due to reduced aerobic capacity and impaired cardiovascular adaptations

Environmental Stress

Exposure to Cold and Altitude

- Reduced ability to generate metabolic heat due to decreased muscle mass and loss of fitness
- Attenuated cutaneous vasoconstriction
- Adapt through behavioral thermoregulation

Longevity and Risk of Injury and Death

- An active lifestyle appears to be associated with a small increase in longevity, but more importantly it leads to a higher quality of life
- There is an increased risk of injury from exercise as people age, and injuries tend to be slower to heal
- The risk of death during exercise is not increased in those who are regularly active but is increased in those who seldom exercise

Aging versus Inactivity

- Aging alone might decrease cardiorespiratory fitness less than the deconditioning that occurs with inactivity, decreased activity, or decreased intensity of training. If body composition and physical activity are kept constant, VO_2max decreases only 2% to 5% per decade, rather than the 10% per decade normally attributed to aging.