Muscular Strength and Endurance

Key Points

- The American College of Sports Medicine recommendations for the level of weekly resistance exercise in healthy adults are:
  - Frequency: at least 2 times per week
  - Intensity: no specific recommendation
  - Duration: at least 1 set of 8 – 12 repetitions for every major muscle group

- Physiologic changes that occur in the body with regular resistance exercise include the following:
  - In lean muscle mass
  - In bone density
  - Muscle capillary density
  - Level of ATP-PC and lactic acid enzymes
  - Ability to use lactic acid as fuel
  - Increased levels of muscle glycogen

- Health benefits that accrue with regular aerobic exercise include the following:
  - In caloric expenditure
  - Risk of osteoporosis, especially with weight-bearing exercise
  - Decreased risk of non insulin-dependent diabetes mellitus
  - Level of stress hormones
  - Anxiety and depression

- Fast-twitch, or white, muscle fibers provide high levels of force, but they fatigue quickly. Slow-twitch, or red, muscle fibers provide a lower level of force, but they are fatigue resistant.

- Isometric contractions occur at the same muscle length
  - Isotonic contractions occur with the same load
  - Isokinetic contractions occur at the same speed
  - Eccentric contractions occur while the muscle is lengthening, such as when a person landing on a hard surface uses their leg muscles as shock absorbers.
Concentric contractions occur while the muscle is shortening, such as when a person picks up an object from a table and lifts it in the air.

- Delayed Onset Muscle Soreness (DOMS) occurs one to two days after the muscles have been overused and is a result of damage to the microscopic elements of the muscle. DOMS is more common with eccentric contractions than concentric contractions. Mild applications of cold therapy immediately after exercise (before the muscles become sore) may help to prevent the onset of DOMS.

- Muscle size and muscle strength are highly correlated. Strength differences between men and women largely disappear when strength is made relative to the cross-sectional area of the muscle.

Reading Comprehension

Reading: Chapter 4

Discuss gender differences in muscular strength.
Define the following terms:
- tendon
- ligament
- repetitions
- repetition maximum
- set
- muscle fiber
- myofibrils
- hypertrophy
- atrophy
- slow-twitch fibers
- fast-twitch fibers
- motor unit
- isometric
- isotonic
- isokinetic
- agonist
- antagonist
- plyometrics
- concentric muscle contraction
eccentric muscle contraction

What are the chief benefits of muscular strength and endurance?

Supplemental Knowledge

Aerobic exercise first became popular in the general population during the 1970’s, when joggers and cyclists first began appearing as a regular feature of the American landscape. The need for resistance exercise (strength training) has not developed the same popular following, but experts agree some form of resistance exercise is vitally important in maintaining lifetime health and fitness levels. In addition, due to Victorian notions regarding “ladylike behavior” and the “proper role” of women in society, strength training has been particularly slow to catch on among teenage girls and adult women. The benefits of resistance exercise, however, are perhaps even greater for women than they are for men.

Like aerobic exercise, resistance exercise first developed as an aspect of sports conditioning. Muscular power is a combination of strength and speed, and power is a vital element of most -ball sports (e.g., baseball, football, volleyball). Although the athlete with the largest muscles is not necessarily the one with the advantage (power is the combination of strength and speed), size and strength are two sides of the same coin. By and large, strength differences between individuals – even between women and men – are a simple reflection of muscle size, and these strength differences largely disappear when strength is expressed relative to the cross-sectional area of the muscle.

To build strength and size a person lifts near-maximal weights (the heaviest weight that can be lifted in 3-6 reps). A low number of repetitions (e.g., 3-6) are incorporated in each set in order to allow the heavy levels of resistance necessary to stimulate muscle growth. In addition, there is normally a large rest interval between sets to allow the body time to recover and display near-maximal effort once again. In general, the person seeking muscle strength will also spend a large amount of time in the weight room, as these gains do not come easily.

When a novice begins weight training, there is normally an initial training period in which the majority of gains are due to the nerves and muscles “learning” how to perform the movements required. This initial period averages about six weeks in length, and, if weight training continues, muscle hypertrophy will begin to take over as the dominant mechanism behind increases in strength. As with most aspects of physical training, the greatest portion of the variation between individuals can be accounted for by genetic background. Each of us is born with a certain number of muscle fibers suitable for adaptation to weight training, and some are born with more of these fibers than others. Although, in theory, a modest increase in the number of muscle fibers could occur with
intense training, this theory has never been documented in humans. For all practical purposes, weight training increases the size of muscle fibers, and not their number.

Fast-twitch muscle fibers are the most likely to hypertrophy. These muscle fibers are the last to be activated, recruited only for strenuous effort, and they produce large volumes of force very quickly. Fast-twitch muscle fibers also fatigue quickly, and so most endurance work is performed by slow-twitch muscle fibers. Slow-twitch fibers are the first to be recruited, but the move at a comparatively slower contraction velocity and produce comparatively lower levels of force. They are highly fatigue-resistant, however, and the relative advantages of each fiber type are best illustrated by comparisons in the animal kingdom. Cats have a large percentage of fast-twitch muscle fibers (also called white muscle fibers), while dogs have a larger percentage of slow-twitch muscle fibers (also called red muscle fibers). Dogs and their cousins (wolves, coyotes, foxes) run their prey down over long distances, while cats and their cousins (lions, tigers, leopards) have to sneak relatively close to their prey and then pounce with a sudden, lighting movement.

Muscle hypertrophy is also limited by the presence of testosterone, a steroid hormone which acts like a key in a lock, allowing large increases in muscle size. For this reason, heavy weight training is NOT likely to be effective in children, and the risk of injury associated with heavy lifts has prompted the medical restriction that those who are still in the process of adolescent development should not lift to maximum. (For simplicity’s sake, we could say that young men or young women should not engage in maximal lifts until they leave high school.)

The difficulty of obtaining increases in muscle size makes many weight lifters vulnerable to the temptation to abuse artificial steroid drugs and other questionable substances. Indeed, the levels of training one must endure to make significant progress in muscle size are such that many weight lifters are among the most gullible consumers in American society, spending large amounts of money on “nutritional supplements” with little or no proven benefit. Because the body already manufactures adequate amounts of testosterone, weight lifters can only achieve an effect by dramatically over-dosing on steroids, 100 times or more the natural level of the hormone. Obviously, such extreme doses cause a great deal of damage to other organs and body systems.

To build muscular endurance a person lifts relatively lighter weights (the heaviest weight that can be lifted in 8-20 reps), using a high number of repetitions (e.g., 8-20) per set, and a short rest interval between sets. In general, a beginner should spend some weeks building muscular endurance before attempting to build muscular strength or size.

A common complaint a day or two after a strenuous weight training session is Delayed Onset Muscle Soreness (DOMS). DOMS occurs more commonly with eccentric contractions, or those actions where the muscle are acting to generate a braking force (as against gravity). In these movements, the microscopic structure of the muscle fibers is particularly susceptible to injury, and the weight lifter walks away from their session “bruised” internally on a microscopic level. The body deals with these injuries just as it would deal with blunt trauma from an outside force, initiating an inflammation reaction. Unfortunately, in addition to the pain associated with DOMS, the inflammation reaction often causes more damage than the initial injury. Weight lifters should avoid DOMS if they can by not working out at such an intensity, but, if one suspects one has gone too far, early application of mild cold therapy (e.g., 10 or 20 minutes of icing the muscle) may decrease the inflammation response and limit the severity of the muscle soreness.
Many women steer away from weight training due to the false assumption such activity will generate large muscles. This is a false fear for almost every woman, as the low levels of testosterone present in her body will not allow muscle hypertrophy to any noticeable extent. Indeed, as mentioned previously, weight training may be particularly beneficial for women. Physiologic changes that occur in the body with regular resistance exercise include an increase in lean muscle mass – making it much easier to control the accumulation of body fat, as significant calories are burned only in the lean body mass – and an increase in bone mineral density, a protection against osteoporosis. Other health benefits of weight training are similar to those of aerobic exercise, including an increase in caloric expenditure, a decreased risk of non insulin-dependent diabetes mellitus, and an increased ability to manage stress, anxiety, and depression.