A basic principle of strength training - the so-called overload principle - was referred to in the scientific literature as early as the late 1800s, and defined in more detail in the 1950s. Muscle strength in previously untrained healthy men and women can be increased provided the training loads exceed sufficiently enough that of the normal daily activity of an individual muscle. However, an important question in strength training concerns the mechanisms responsible for training-induced increases in strength and/or power. Examination of these aspects must take into consideration the interaction between neuromotoric, hypertrophic and various mechanical factors (Komi 1986).

Progressive heavy resistance strength training leads to both functional and structural adaptations in the neuromuscular system. It is a common finding that a major part of the early increases in maximal strength during the first weeks of heavy resistance strength training in previously untrained male and female subjects may be accounted for largely by specific adaptations in the facilitatory and/or inhibitory neural pathways acting at various levels in the nervous system (Moritani & DeVries 1979, Komi 1986, Sale 1991, Hakkinen 1994, Enoka 1995). Although the actual forms of the neural adaptations are difficult to reveal, largely due to technical limitations (Enoka 1995), strength training does change both the quantity and quality of activation so that 1) activation of the prime movers is increased and/or that there is 2) an improved coactivation of the synergists and/or 3) a reduction in coactivation of the antagonist muscles. Training-induced increases in the quantity of EMG would usually suggest that the number of motor units recruited have increased and/or motor units are firing at higher rates or some combination of the two have taken place (Sale 1991).

To induce increases in explosive force (power) production the overload principle must be modified to give special attention to the higher action/movement velocity of the exercises performed. Power type strength training-induced adaptations in rapid voluntary and/or reflexly induced neural activation of the trained muscles can be observed during high velocity concentric exercises, IEMG-time curve of the isometric action as well as in various stretch-shortening cycle exercises (Hakkinen 1994). Nevertheless, neural adaptations in voluntary and/or reflexly induced muscle actions are primarily responsible for several experimental findings of strength and/or power gains with only minor muscular hypertrophy. Strength and/or power development during short term strength training of a few weeks and/or a few months takes also place to about a same degree in men and women. It is well documented that gradually increasing muscular hypertrophy contributes to strength development as heavy resistance strength training proceeds. The increase in the cross-sectional area of the muscle during strength training comes primarily from the increase in size of individual muscle fibres of both fast and slow twitch types and to a some degree from the increase in non-contractile connective tissue between the fibres, probably with no addition in fibre number (McDougall 1991). Although conversion of fast twitch type subunits may take place, it is unlikely that strength training would alter the proportions of the two main fibre types (McDougall 1991). A requirement for training-induced hypertrophy is high tension of a muscle for a sufficient duration which somehow provides the signal for increased uptake of amino acids and enhanced synthesis of contractile proteins. Secondly, the repeated process of damage and repair during and between training sessions may result in an overshoot of protein synthesis (McDougall 1991). The basic serum
levels of endogeneous anabolic and/or catabolic hormones remain during strength training usually within the normal physiological range but due to basic hormonal differences between men and women the ultimate degree of muscle hypertrophy and strength development will be less in women than in men during prolonged strength training of several months and/or years (Hakkinen 1994).

Human muscle strength and power decrease with increasing age, especially at the onset of the sixth decade in both sexes. The decrease in strength seems to be related to a great extent to the reduction in muscle mass, since aging is associated with alterations in hormone balance and often with a decrease in the intensity of daily physical activities. The decline in muscle mass may take place due to both a reduction in the size of individual muscle fibres, especially of fast twitch types and a loss of individual fibres (Lexell et al 1988). However, progressive strength training in middle-aged and elderly men and women can lead to substantial increases in their muscle strength. Strength gains in older subjects during the initials weeks of strength training are due to improved neural recruitment patterns (Moritani & DeVries 1980, Hakkinen & Hakkinen 1995). However, skeletal muscles of elderly men and women retain the capacity to undergo training-induced hypertrophy of both fibre types, when the loading intensity and the duration of the strength training are sufficient (Frontera et al 1988). The principle of the specificity of heavy resistance vs. power type strength training with regard to the shapes of the force-time and/or force-velocity curves of the trained muscles holds true also among elderly subjects (Hakkinen 1994). Proper strength and/or modified power type strength training can be utilized as a preventive, therapeutic and rehabilitative method to optimize neuromuscular performance among elderly people. The benefits of maintaining or improving strength or power in aging people include correction of gait disturbances, prevention of falls, improved mobility as well as improved performance of activities of daily living and increased capacity of independent living.

REFERENCES