10.1 Strong Muscles Make and Maintain Strong Bones!

The human body is equipped with an impressive apparatus to overcome the forces of natural gravity on planet earth. This apparatus consists of the bones and joints of the skeleton, together with the tendons and muscles. Moreover, the physical stimuli of pressure, weight, and the “push and pull” of movements – controlled and uncontrolled, sudden and slow, continuous and interrupted – directly stimulate the bone cells to form new bone and thereby increase bone mass. Without adequate physical activity, 5–10% of the muscle mass may be lost per annum. This in turn leads to a decrease in bone mass. It should be noted that physical activity is just as, if not more, important for the prevention of osteoporosis as medication.

Immobilization, bed rest, spinal cord injury and a sedentary lifestyle inevitably induce rapid bone loss. The ultimate test of evaluating the effects of weight-bearing activity on bone occurred in space, where there is zero gravity. Before preventive measures were introduced, post-flight bone density of astronauts showed significant decrease in density after only 4–14 days in outer space!

In order to benefit the bones, exercise must be weight-bearing, together with special training to strengthen the muscles. Weight-bearing exercise is any type of exercise in which the bones must support the weight of the body against gravity. The most effective activities are those which challenge gravity such as climbing, walking, jogging, running, volleyball, basketball and especially going up stairs. Therefore, use the legs and not the lift. Whoever does not manage at least 30 min walking daily, should at least do some regular exercise at home. Giving up half an hour of TV every day is all that it takes! The importance of sustained exercise, especially with high impact loading, cannot be overemphasized for the prevention of osteoporosis as well as for its therapy, which has been extensively documented in various studies. No matter how you look at it, an effective exercise program takes approximately 3 h per week. Everybody should be able to manage that! As the age-old saying has it: “Where there’s a will, there’s a way!”

Muscle strength in older individuals responds dramatically to resistance exercise. Strength gains vary from 30% to more than 100% in various muscle groups. Training-induced strength gains are initially rapid but tend to plateau after 3 months, even with progressive increases in training loads. Thus, muscle strength can be improved and can also be maintained in older people without high-intensity training schedules.

The sense or the automatic ability to keep one’s balance is gradually but systematically reduced from about 30 years onwards. However, the body is able to compensate, so that this deficit only becomes noticeable if and when other senses such as sight and hearing are also impaired. In osteoporotic patients, the consequences of the decreased ability to balance include falls...
and possibly fractures. Clearly, appropriate measures must be taken to avoid this. Balance can be tested with the “get up and go test”: Get up from a chair without using arms; walk several steps; turn around and walk back to the chair; sit without using arms. If this is accomplished successfully, balance is not a problem. Randomized clinical trials have shown that exercise can reduce the risk of falls by as much as 25%. Prospective observational studies suggest a U-shaped relationship of an increased risk of falls among people who are either very frail or sedentary, or extremely active. Trials have also shown that current or past physical activity is associated with a 20–60% reduction in hip fractures, but only a modest reduction in vertebral fractures.

10.2 The Muscle–Bone Unit and Sarcopenia

Recent studies (mainly in 2008) have presented evidence that intra-uterine and post-natal growth patterns and growth are associated with body composition later in life and this in turn with musculoskeletal disorders and their consequences. Most importantly, these include sarcopenia and osteoporosis. Moreover, a functional approach to densitometry has addressed the question of the mutual adaptation of muscle force with bone strength, and of how deviations of this adaptation may lead to disorders of bone, especially in pediatrics. Subsequently, taking into account Frost’s “Mechanostat Hypothesis” as well as the modifications induced by hormonal signals, the quantified relationship between muscle force and bone strength has been suggested as a diagnostic parameter for distinguishing between primary and secondary disorders of bone. Other studies have reported on the association between birth weight and body mass index (BMI) with a tendency for large babies to become obese adults, while a low birth weight poses a risk for later development of the metabolic syndrome, itself associated with increased risk of osteoporosis. However, the results of many of these studies on the relationship of birth weight and its impact later in life on adult body composition still require confirmation.

There is one aspect of the muscle–bone unit which has global consequences and on which there is global agreement: Sarcopenia! Sarcopenia is the age-related loss of skeletal muscle mass with concomitant decrease in muscle strength leading to a reduction in physical activity, which, with advancing age, is a major cause of osteoporosis and other disabilities (Fig. 10.1). Sarcopenia is internationally recognized as a major feature of human senescence. The mechanisms of this muscle loss are still under investigation, but various aspects and pathways have been described. These include biochemical aspects such as reduction in myosin heavy chain protein synthesis, changes in hormonal and neural activities, impaired post-traumatic regeneration, oxidative stress, mitochondrial abnormalities and dysfunctions and myositic apoptosis, as well as apoptotic loss of single nuclei in multinucleated cells. Decrease in telomere length with ageing may also occur in both muscle and bone cells. The good news is that long-term training within normal limits is not associated with abnormal telomere shortening in muscles, and in the elderly regular physical activity is also not associated with accelerated telomere loss in muscles and also not in leukocytes. In contrast, a sedentary lifestyle does have an effect on telomere length and may accelerate the ageing process! So that at least is one physiological risk factor that can be controlled!! Just get up and do it! Also important is endocrine-immune dysfunction involving both inflammatory and other cytokines, lifestyle factors, i.e. smoking, and, most significantly, nutritional deficiencies such as inadequate dietary protein and vitamins, in particular vitamin D. In addition to its function as a major regulator of calcium homeostasis, in the skeletal muscle actions of vitamin D are involved in protein synthesis, and in the kinetics of muscular con-