Ageing of Musculoskeletal System

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Ageing background

What is ageing?

Ageing or aging or senescence is interchangeable term used for the biological processes or sequences that progress throughout life. However, its meaning has always been limited to the later sequences of life that possess the slow, insidious declines in structure and function, which usually establish after sexual maturity.[1-5] As for biological ageing, the processes commence at or before conception by the models of "wear and tear", programmed change, or cumulative stochastic damage.[5] If determining ageing by the declines in structure and function, the beginning of ageing can be defined by using survival curves[3] or sexual maturity and the adult phenotype,[2] which will not be discussed here.

Mechanisms of ageing

The maximum lifespan of each species is depended on the genetic heterogeneity and variable environmental influences. Many theories on the mechanisms of ageing have been developed; however, they can be divided into two main categories. Firstly, aging is the result of the sequential switching on and off of certain genes, which is postulated by Program theories. Another category, Errors theories, emphasize that aging is the outcome of both random accumulation of error mutations and wear and tear of tissues and organs.[3]

Successful or healthy ageing

The definitions of successful ageing vary among studies because their multidimensional aspects. Despite the variability, the majority of definitions are based on the absence of disease and disability with mental well-being.[6-8] The causes of the disability are mostly of the musculoskeletal system.

Ageing of musculoskeletal system

Musculoskeletal system functions as the frame work of the body and also driving the body to move. Bones link into the frame work, whereas muscles and the neural system move and protect it. The links are the joints, of the most important, cartilaginous joints. Ageing of musculoskeletal system takes part in these structures.

Cellular ageing

Throughout the lifespan, cell turnover and replacement occurs in many tissues to maintain the function. Ageing affects at the cellular level by apoptosis and/or cell senescence resulting in reduced numbers of fully functional cells, accompanied by altered matrix production, altered cellular composition, altered microenvironments, and altered responses to the environment.[1]

Bone ageing

Three types of cells are responded for bone ageing. Osteoblasts (bone-building cells) and osteocytes (mature bone cells) build and maintain bone mass, whereas osteoclasts (bone-destroying cells) remove bone mass. The changes at cellular level with ageing alter the numbers of fully functional cells and also matrix production of osteoblasts and osteocytes. As for the bone, the reduction of estrogen, the hormone which protects the bone, ameliorates the bone loss. Moreover, the accumulation of advanced glycation end products (AGEs) and the reduction of antioxidants (such as vitamins A, C, and E) in serum alter the bone formation.[1] The result of ageing on bone is osteopenia to osteoporosis (loss of bone mass and architecture), weakening the skeletal framework.

Cartilage ageing

In contrast to the bone, cell turnover and replacement in the cartilage is relatively low. Ageing cartilage is generally the alteration of cell function, the matrix formation. Changes in the extracellular matrix composition or configuration alter the ability of cartilage to withstand mechanical stress.[1]

Muscle and neuromuscular control ageing

Muscle changes in humans start in the fourth decade of life by the reduction in the synthesis rates of many muscle proteins, specifically of myosin heavy chain and mitochondrial proteins.[9,10] In addition to the changes of specific proteins, enzyme activities, ion content and regulation, oxidative stress and free radical, nutrition and caloric restriction, and exercise and limb mobilization contribute to the changes of ageing muscles.[10]

Ageing of muscle and neuromuscular control system are closely related as the alterations in spinal cord motor neurones and at the neuromuscular junction have been identified as evidence of denervation in skeletal muscles. Age-related changes in the spinal cord that are the reduction of neurones' size and number have been reported.[11] There are also significant age-related changes in the neuromuscular reflex system, but not with significant decrease in motor-neuronal excitability. The alternations in motor control associate with weaker and slower muscle

force generation.[12]

For the higher control, there is no significant loss of cortical neurons with age, but evidently loss of myelin integrity that reduces conduction velocity along nerve fibers. This causes a disruption in the timing of sequential events in neuronal circuits, and could lead to slowing of responses.[13]

Consequently, ageing of muscle and neuromuscular control system lead to weakness and slowing of responses of muscles in protecting the joints.

Common musculoskeletal problems of ageing

Common musculoskeletal problems of elderly are osteoporosis, osteoarthritis and falls and fractures. All problems are closely related and affected each other.

Osteopenia or osteoporosis

Osteopenia or osteoporosis is the reduction of bone mass and alteration in bone architecture resulting in weakening of the skeletal framework. Osteopenia or osteoporosis by itself causes no problems until the bone loses its function of support (fracture) by excessive stresses or loads.

Osteoarthritis

Osteoarthritis is the degeneration of joints by abnormal mechanical stress on joint cartilage. Abnormal stress can arise from overloading or repetitive loading or loss of protective mechanisms from weakness of muscles. The lack of load distribution mechanisms of the joints such as joint stiffness can also turn normal external loading into overloading in any area of the joint cartilage.[14] Together with ageing changes of cartilage, muscles and neuromuscular control system (protective mechanisms), wear and tear of the articular cartilage occurs, leading to narrowing of the joint space (thinning of cartilage). Subsequently, inflammation occurs, and the joint is filled with inflamed synovial fluid. The joint becomes loose or unstable and it needs additional muscle activities (synergistic muscles) to stabilize it. Excessive use of synergistic muscles causes abnormal stress on the muscles themselves and also on the articular cartilage as a vicious circle. Pain from the loose or unstable joint comes from impingement and/or stretching of the periarticular tissues and also excessive use of muscles to stabilize the loose or unstable joint.

Osteoarthritis or degenerative arthritis of the spine is more complicated as the spine is a column of joints, which needs many muscular systems to stabilize it. Stability of the spine is mainly relied on the muscles and the neuromuscular control system to balance all the forces or loads upon the system.[15] Degenerative arthritis of the spine causes excessive use of synergistic muscular systems that becomes tightness. The abnormalities of the synergistic muscular systems, which link to the extremities as the kinetic chain, alter the stability of the extremities and vice versa.[14,16] In addition, severe degenerative spine compromises the neural structure causing muscle weakness and sensory loss, which are causes of falls.

Falls and fractures

Falls in the elderly with osteoporosis cause fracture, which is associated with considerable morbidity and mortality. The risk factors that can identify from the ageing of musculoskeletal system are osteoporosis, muscle weakness, balance deficit, gait deficit, and arthritis. Other risk factors of falls identified are history of fall, visual deficit, use of assistive device, impaired activities of daily living, depression (medication), cognitive impairment and age over 80 years.[17] The intrinsic factors especially ageing of musculoskeletal system are preventable.

Prevention of musculoskeletal problems of ageing

Ageing of the musculoskeletal system or other system is basically the declination of functional cells and function in each system. Extrinsic factors, such as overloading and/or repetitive loading, magnify normal ageing processes to become problems or diseases. Muscles and neuromuscular control system are the key elements on protecting the musculoskeletal system. Strong and balanced muscles help protecting the joints by reducing the loads and distributing the loads equally in case that there is no limitation of the range of motion of the joints. The strategy in prevention of the musculoskeletal problems of ageing is to reduce the extrinsic factors and to improve the musculoskeletal quality and function.

Exercises to improve function

Exercises are principal basics to improve the quality and function of the bones, muscles and neuromuscular control system. Both aerobic exercise and resistant exercise enhance muscle protein synthesis and mitochondrial biogenesis.[9] Stretching exercise helps in the case of limitation of motion and also balancing the muscles. Sensorimotor training or training of proprioceptive sense to restore normal muscle firing patterns and reflexive stabilization is also important in preventing excessive range of motion, which is a cause of injury.[16] A combination of exercises is necessary to maintain the healthy musculoskeletal system.

Nutrition

Nutrition is as important as exercises. Calcium and vitamin D are necessary not only for the bones, but also for muscles and neuromuscular system to function properly. The supplement of calcium is recommended in person age > 50 years old together with vitamin D for proper calcium metabolism. The supplement of glucosamine sulfate and/or chondroitin sulfate, although it is not widely recommended, may improve the quality and function of the cartilage reducing the incidence of osteoarthritis.

Reduction of stresses or loads

The most important strategy is to reduce the extrinsic factors that deteriorate the ageing process. Overweight or obesity affects the musculoskeletal system by increasing the loads to the joints and also weakening the muscles. Another hidden deteriorating factor is poor posture such as head-forward or hyperlordosis postures. These poor postures increase stresses to the musculoskeletal system and magnify the degenerative processes. Weight reduction and posture or behavior correction are essential parts in preventing the musculoskeletal problems of ageing.

CONCLUSION

Ageing processes may be programmed or being as a result of error accumulation resulting in the reduction in the fully function cells. Ageing of the musculoskeletal system with the deteriorating factors, gives rise to osteoporosis, osteoarthritis, falls and fractures. The prevention of the musculoskeletal problems of ageing is to exercises and having adequate nutrition to maintain the function of the musculoskeletal system as well as the reduction of the deteriorating factors by weight reduction and posture or behavior correction.

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Eat Well for Better Ageing

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Introduction

Aging probably begins before birth. The phenomenon of aging probably results from automatic cellular changes and environmental influences, such as DNA damage, free-radical reactions, hormonal changes, alterations in immune function, elevated blood glucose, and excess energy intake. Eating is one of our great pleasures, eating well is also a means to get healthy. Most of us want a long, productive life and free of illness. The World Health Organization defined older persons as people over 60 years of age. As we age, our appetites may decline but our nutritional needs do not. We can slow the development of coronary heart disease, hypertension and strokes, type 2 diabetes, osteoporosis, and other chronic diseases, and in some cases even prevent these diseases by taking a diet that works against them.[1] Much can be learned from healthy older people whose attention to health and physical activity-along with retirement years.[2] Delaying the symptoms of disabilities from chronic disease for as many years of life as possible is a successful aging life goal.

Ageing in Thailand

The age profiles depict changes in population structure from a pyramid in 1960 towards a bell shape in the twenty-first century. The aging population are increasing as shown in Table 1. Fifty-five percent of the elderly Thais are women. In addition, the majority (81.1%) of the elderly Thais live in the rural areas. A high proportion of the elderly males live with their spouses. Life expectancy has increased dramatically in the 20th century. These gains were largely due to the eradication and control of numerous infectious diseases, improvements in medicine, public health, and nutrition.

TABLE 1. The population of aging Thais.

	2000	2005	2010	2015	2020
Total population	62.1	64.8	67.0	68.6	69.9
Aged 60years and over	5.6	6.3	7.4	9.1	11.3
Aged 80years and over	0.4	0.5	0.7	0.9	1.0

Nutrients and aging

The latest Dietary Reference Intakes for nutrients and energy include a category for both men and women who are 51 to 70 years of age and more than 70 years of age are shown in Table 1. Because DRIs apply only to the healthy people, many older people-for example, those who have ulcers or are heavy aspirin users- are not covered by these standards. Indeed, it is particularly tricky to develop nutrient standards that are valid for most older people because so many are ill and/or regularly take medication. Because the lifestyle of an active older person can differ considerably from that of a nursing home resident, establishing nutrient needs during these wide age ranges is problematic.

A well-planned diet that follows the Food Guide Pyramid[3] can meet all nutrient needs for older people within about 1600 to 1800 kcal, except for probably vitamin D, vitamin B-12, folate and calcium. (Fig 1) As we age, our nutrient needs change. For example, calcium needs increase after age 50 for males and females. It would take at least three servings from milk, yogurt and cheese group for calcium - a recommendation that most older people would find difficult to meet. Calcium-fortified foods can help when necessary. Vitamin B-12 needs also change after age 50, about 10 to 30% of older people may malabsorb food-bound vitamin B-12 because of reduced