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PHYSICAL ACTIVITY, SPORT AND HEALTH THROUGHOUT LIFE: THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY, AGING AND HEALTH

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PHYSICAL ACTIVITY, SPORT AND HEALTH THROUGHOUT LIFE: THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY, AGING AND HEALTH

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SUMMARY

What are the benefits of physical activity for heath? How is physical activity related to aging? Do these benefits differ with the type of exercise? What happens to performance as we age? We will examine the answers to these questions here.

The longevity of both physically active and sedentary individuals is determined by the interplay between environmental factors and the person's genetic makeup. Environmental factors, including physical activity, influence the expression of genes, which can alter growth rates, the rate of aging, and longevity.

This text concerns the effects of aging and physical activity on the body and on overall health. Where available, we present information from studies of elite athletes who have been exercising at a high level throughout their life, but information on this topic is sparse. First, however, we define aging and then look at some of the organs and other factors involved in performing physical exercise, and how they are affected by the primary aging process.

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TAKE HOME MESSAGES:

- Physical inactivity reduces health and longevity through its influence on secondary aging (development of disease).
- Girls who exercise during the years when most bone is laid down have higher bone mass than that of their sedentary counterparts.
- Maximal aerobic power begins to decrease from about 35 years of age, which eventually makes the ordinary activities of independent daily life intolerably fatiguing in elderly people; progressive aerobic training in elderly people can delay loss of independence by as much as 10–12 years.
- Physical activity reduces the risk of many diseases in later life, including osteoporosis, cardiovascular disease, diabetes, some cancers and, possibly, cognitive decline and dementia; it also has positive effects on balance and functional capacity.
- Women who exercise regularly throughout life could be physiologically 20 to 30 years younger than their sedentary counterparts.

WHAT IS AGING?

The definition of aging is complicated by the occurrence of various diseases that modify body functions and tissue structures. Diseases related to structural and functional changes that are common in older people are often hard to distinguish from the aging process per se. The rate of aging is strongly influenced by many disease processes and environmental factors. Moreover, different tissues age at different rates.

The combination of loss of postmitotic[1] cells in the brain and heart, a general decline in cellular function, and harmful changes in the extracellular matrix[2], is termed 'primary aging'. 'Secondary aging' is caused by diseases and environmental factors such as smoking and exposure to ultraviolet radiation. To date, nothing has been proven to slow or reverse the primary aging process in humans, but factors known to affect longevity do so by their influence on disease development – part of secondary aging. One such factor is physical inactivity. It has long been known that physical activity is a powerful way to promote all aspects of human health.

The musculoskeletal system: Loss of muscle and bone mass

With advancing age, the fat-free mass in the body progressively decreases, mostly due to loss of muscle and bone mass. This change is part of the primary aging process.

Loss of muscle mass (sarcopaenia) is characterised by a reduction in muscle mass and strength. This process starts from as early as 40 years old in humans, and eventually causes frailty and disability. Distinct muscle changes at the cellular level include a decrease in type II muscle fibres and a decrease in the mRNA levels in the myosin heavy chains IIa and IIx.[3] In addition, a reduction in whole-body protein turnover, mixed muscle protein synthesis, and synthesis of myosin heavy chains and mitochondrial[4] protein has been reported.

The various tissues and organs respond differently to aging; generally, more age-related changes occur in tissues that burn lots of fuel to produce large quantities of energy. There is considerable evidence that the rate of muscle protein synthesis responds to exercise. In studies performed in both young and old people, resistance exercise (strength training) stimulated the synthesis of mixed muscle proteins, which were measured after 2 weeks of training and after 3 months of training. Also, synthesis of mixed muscle proteins has been shown to increase after 4 months of aerobic exercise.

Previously, it was thought that bone mass in women remained unchanged between its peak in young adulthood and menopause. However, large epidemiological studies have now clearly confirmed that bone loss in women begins immediately after peak bone mass is reached, long before any change in secretion of the reproductive (sex) hormones.

During menopause, secretion of these hormones dramatically changes, which has damaging effects on bone that are manifested in two distinct phases. The oestrogen and progesterone decline–withdrawal that occurs during the several years after menopause (early phase) is marked by rapid bone loss, increased calcium concentrations in the blood, and increased calcium excretion via the kidneys. During the late postmenopausal period, the rate of bone loss declines to that seen in aging men. At this stage, the loss of bone minerals is related

1 *Postmitotic* cells are no longer able to divide to produce new cells.
2 The *extracellular matrix* is the environment surrounding the cells in the body; it can be either fluid or solid.
3 *Myosin* is a protein involved in the contraction of the muscle fibres. *mRNA* is involved in protein manufacture in the cells.
4 The *mitochondria* are the 'powerhouses' of the cells and produce energy to drive the cellular functions.

to reduced calcium absorption in the gut and reduced reabsorption in the kidneys, both of which are due to the absence of oestrogen.

Maximal oxygen uptake

Population observations in sedentary women show that maximum aerobic power, measured as maximal oxygen uptake (VO_2 max), begins to decrease at around 35 years of age, from about 38 $mL \cdot kg^{-1} \cdot min^{-1}$ in the young adult to about 25 $mL \cdot kg^{-1} \cdot min^{-1}$) at age 60. This equates to a loss of about 5 $mL \cdot kg^{-1} \cdot min^{-1}$ per decade. Data suggest that similar losses continue in old and very old humans. If this loss continues into old age, a point is reached – about 15-18 $mL \cdot kg^{-1} \cdot min^{-1}$ – at which the ordinary activities of independent daily life become intolerably fatiguing. In sedentary people, this occurs between 80 and 85 years of age. Progressive aerobic training can boost the aerobic power of elderly people by at least 5–6 $mL \cdot kg^{-1} \cdot min^{-1}$, potentially delaying the loss of independence and decreasing the biological age by as much as 10–12 years.

Balance

Balance is an important component of motor skills, from maintaining posture to performing complex sports skills, and is categorised into static and dynamic balance. Static balance operates when stability is maintained in one motionless body position, whereas dynamic balance refers to both maintaining stability during motion and to re-establishing stability through a rapid, consecutive series of positions. In order to maintain both static and dynamic balance, the brain integrates sensory information from the visual system, the vestibular system (the balance organ in the inner ear), and the system of receptors throughout the body that detect the position of the body in space. The ability to maintain balance diminishes with age, but the reason why elderly people have difficulty is apparently very complex.

PHYSICAL ACTIVITY AND THE AGING PROCESS

Physical activity and menopause

In women from Western countries, natural menopause generally occurs around 51–52 years of age. Menopause is defined as the period in which an absence of the menstrual cycle (amenorrhoea) occurs for at least 12 consecutive months. Eggs (ova) no longer develop in the follicles in the ovaries, and the menstrual cycle cannot be maintained.

Another important aspect of menopause is the natural decline of the ovarian hormones, mainly oestrogen, that begins before menopause proper (peri-menopause). This decline is associated with a suite of symptoms that includes hot flashes (flushes), night sweats, sleep disturbance, joint and muscle pain, weight gain, dizziness, heart palpitations, urinary incontinence, poor memory, anxiety and depression.

No evidence from rigorous trials indicates that exercise is effective in reducing hot flashes and night sweats in menopausal women. However, some results suggest that exercise may be more effective than no treatment at all. Alternative forms of exercise, such as yoga, may also be beneficial. Some results indicate that, compared to sedentary women, those taking part in regular physical exercise have a lower prevalence of vasomotor symptoms such as hot flashes and palpitations, as well as psychological symptoms including depression, anxiety, irritability and mood swings. Still, more good-quality studies are needed.

Physical activity and osteoporosis

Osteoporosis is a metabolic disorder of the bones due to loss of both bone mineral and bone matrix in equal proportions. The result is a frail bone with reduced weight-bearing ability. The peak bone density achieved during the development and growth period (especially at the time of puberty) and subsequent bone loss in adulthood are crucial to bone mineral density throughout life. Because the human skeleton before puberty is quite sensitive to mechanical stimulation from physical activity, regular exercise during this time maximises the peak bone mass. Thus, physical activity has a significant role in maximising peak bone mass and reducing the subsequent bone loss. Experiments on laboratory animals have shown that mechanical loading of the skeleton is necessary to maintain bone mass. Furthermore, observational studies find that athletes have higher bone mass than that of their sedentary counterparts.

The load exerted on the bones by gravity and the mechanical stresses applied by the muscles are necessary to stimulate the bones to maintain their structural and functional strength. Weight-bearing activity stimulates bone remodelling, whereas lack of mechanical stimulation – as seen, for example, in paralysed limbs – can lead to osteoporosis. The two types of exercise generally recommended for osteoporosis are weight-bearing exercises and strength training (also called resistance exercise). Briefly, the degree of the loading, the type and intensity of the activity, and the number of repetitions seem to be important factors associated with the effect of physical activity on bone.

Girls who exercise during the years when most bone is laid down have higher bone mass than that of their sedentary counterparts. This effect has lasting benefits for bone mass and density later in life, as measured in the lumbar spine and proximal femur. Exercise performed during late adulthood only increases bone mass modestly, if at all. The main effect at this stage is to maintain bone mass.

Physical fitness (capacity)

Physical activity has long been known to powerfully promote all aspects of human health. Studies suggest that the body's continual adjustment to physical activity can markedly reduce the rate of deterioration in physiological, functional and exercise capacities that would otherwise occur with aging. The peak exercise workload that can be achieved always decreases with aging. However, the cardiovascular and musculoskeletal adjustments to long-term aerobic exercise allow the trained individual to continue to perform at higher sub-maximal workloads with smaller increases in heart rate, blood pressure and respiratory effort, and less overall and musculoskeletal fatigue, compared to the performance of untrained people. The adaptations to cardiovascular (aerobic) exercise can prevent much of the day-to-day functional limitations that might otherwise be imposed by the physiological changes associated with aging and disuse.

As already mentioned, maximal oxygen uptake decreases with age despite activity status, but the absolute cardio-respiratory capacity of veteran endurance athletes is higher than that of age-matched non-athletes. Some evidence also suggests that young and old people differ in their ability to recover from exhausting exercise in the short term, as measured by physiological parameters such as heart and respiratory rates. That is, for a given exercise stimulus, an older adult takes longer to return to baseline levels than a younger person does.

Physical activity and balance

Learning a sport and years of training improve the control of both static and dynamic balance in daily life activities. However, do athletes have better balance than non-athletes, and does the balance control of athletes vary between sports? Based on studies of both sportsmen and sportswomen, gymnasts tend to have the best balance control, followed by football players, swimmers and basketball players. Because the aging process affects muscle mass, old gymnasts most likely have better balance than that of their sedentary counterparts. In rifle shooting, football and golf, elite athletes showed better balance than that of their less skilled counterparts. However, this was not the case in alpine skiing, surfing and judo. Impact enhance

Physical activity and mental capacity

Results from observational studies suggest that physical activity reduces the risk of cognitive decline and dementia in later life. These findings are not yet adequately confirmed by data from rigorous clinical trials. However, we still do not understand how physical activity decrease the rate of cognitive decline. Future studies are required to understand the duration, intensity, and types of exercise that better improve cognitive functions in older adults.

Physical activity and overall health

The cardiovascular benefits of exercise are well known. Overwhelming evidence from various kinds of studies indicates that cardiovascular disease is largely related to physical inactivity, and that exercise plays a beneficial role in prevention and treatment.

Data indicate that aging impairs vascular (blood vessel) function and is associated with detrimental changes that promote thickening and hardening of the walls of arteries. These effects are apparent at all major functional levels of the arterial tree (network). Current evidence indicates that physical activity and fitness can delay or even reverse these effects. Physical training, in this context, represents a direct and particularly efficient form of vascular medicine.

In contrast, the impact of lifelong endurance training at a very high level is less well understood. For instance, veteran athletes may have an increased risk of developing supraventricular arrhythmias[5] due to exercise-induced physical changes in the heart and its neurological (nervous) control. However, the relationship between ventricular arrhythmias and sudden cardiac death in athletes without any obvious heart disease is controversial. Furthermore, the origins and clinical significance of complex ventricular arrhythmias in veteran athletes are not clear; rigorous studies are required of a large number of veteran athletes throughout the course of their lives, especially those experiencing arrhythmias in later life.

Apart from the role of physical activity in the primary prevention of cardiovascular disease, there is also strong evidence that it reduces the incidence of diabetes and some cancers in women. In addition, women who exercise regularly throughout life could be physiologically 20 to 30 years younger than their sedentary counterparts.

Different types of exercise result in different adaptive responses, all of which have important effects on secondary aging and quality of life. Gymnastics and various ball games, for

5 *Supraventricular arrhythmias* are abnormalities in the heart rhythm originating in the upper chambers (atria) of the heart, whereas *ventricular arrhythmias* originate in the lower chambers (ventricles), especially the left ventricle.

example, improve agility, coordination and balance. These types of exercise induce adaptation in the central nervous system. Stretching exercises such as yoga promote flexibility. Resistance exercise such as weight training increases muscle mass and strength. Endurance exercise such as cycling, long-distance running and swimming induces adaptive changes in both the cardiovascular system and skeletal muscle. Unlike weight training, this form of exercise does not cause muscle hypertrophy (increased size); instead, it increases the capacity of the skeletal muscle for aerobic metabolism (energy production).

Clearly, exercise induces positive effects on women's health and reduces the risk of a number of diseases, including osteoporosis, cardiovascular disease and mental health problems. Therefore, most peri-menopausal and postmenopausal women should be encouraged to continue or take up physical exercise on a regular basis.

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