

Aerobic Exercise Effects on the Functional Capacity of the Aged.

Moran Sciamama-Saghiv

Human Performance Department,
University of Texas Permian Basin, Texas, USA

The aging process is viewed as a progressive decline in health with an increased likelihood of morbidity, on the other hand, successful aging is a function of both genetic and environmental factors (1). Aging is a multi-factorial process that ultimately induces a decline in physiological functioning, causing a decreased health-span, quality of life and independence for older adults. Aging influences on work capacity and physical performance during exercise have been widely investigated. It has been found that aging induces changes in the heart, lungs and skeletal muscles which reduce physical performance with advancing age (2). Myocardial functional changes with aging in sedentary adults include a decline in maximum heart rate, stroke volume, and myocardial contractility, and an increase in peripheral vascular resistance. The changes in structure and function of the cardiovascular system result in maximal oxygen uptake decline, which is the best single indicator of physical working capacity (3). The annual decline rate of decay in maximal oxygen uptake for the general population is estimated to be $0.4-0.5 \text{ mL O}_2 \cdot \text{kg}^{-1} \cdot \text{min}^{-1} \cdot \text{year}^{-1}$. The highest rates of decline in maximal oxygen uptake are in those individuals that have reduced their levels of physical activity as they age. The aging-related decline in maximal oxygen uptake is associated with changes in oxygen delivery (respiratory function and cardiac output) and oxygen extraction from the blood reaching the working muscles (arterio-venous oxygen difference, $[(a-v)\text{O}_2 \text{ difference}]$), leading to an estimated decline in maximal oxygen uptake of up to 20% per decade in older, sedentary adults (4). The higher the volume of blood pumped to the periphery, the greater potential for oxygen transport and uptake (5). Maximal heart rate rather than stroke volume has been shown to be more related to the decline in cardiac output with age during maximal exercise (6).

Loss of muscle fibers and speed of movement may not be uniform throughout the body. It has been suggested that the muscles of the legs are affected to a greater degree by atrophy (7). In addition, compared to young individuals, blood flow in exercising muscles is lower in older men at every submaximal workload. Leg blood flow was $4.46 \text{ L} \cdot \text{min}^{-1}$ during maximal exercise for the older men, compared with $5.57 \text{ L} \cdot \text{min}^{-1}$ in the younger men at a lower, submaximal workload (8). This would reduce the ability of older people to increase oxygen uptake (in contrast to young individuals), since leg blood flow increases linearly during submaximal exercise with increasing workload and function during submaximal exercise of a fixed absolute work rate is similar for younger and older individuals. Mitochondrial density was found to be lower in skeletal muscles of older individuals, which could further diminish capacity for endurance work. Thus, it may be that the aging-related atrophy of skeletal muscle plays some role in the aging-related decline in $(a-v) \text{ O}_2$ difference (9). Arterio-venous oxygen difference is a peripheral mechanism that contributes to the age-related decline in maximal oxygen uptake. Relative to young adults, maximal $(a-v) \text{ O}_2$ difference of older adults is reduced by approximately 10% (6). If oxygen transport is indeed limited by maximal cardiac output, this

may be calculated as the product of maximal heart rate, (a-v) O₂ difference, and maximal stroke volume.

Apart from genetic endowment, an individual must also interact with environmental factors associated with longevity. One of these factors includes maintaining high level of physical activity (10), whereby an individual increases the level of physical activity above what is required for normal daily activity. There is growing evidence from longitudinal and cross-sectional studies that chronic endurance training will attenuate the decline in maximal oxygen uptake associated with age (10). In addition, the importance of aerobic exercise as a tool to reduce the risk of various chronic degenerative diseases has been conclusively established in the last decades. Moreover, fitness level can be a true marker of regular physical activity. Aerobic ability is composed of various components such as: cardiopulmonary capacity, body composition, flexibility, muscular strength and endurance. With increasing age, at the sixth or seventh decades of life, muscle mass of humans is decreased significantly (1). Reduction in muscle mass is a major factor in the decline of maximal oxygen uptake, indicating the cardiopulmonary fitness of the individual (3), bringing about a reduction in physical performance (11).

Following aerobic exercise training, untrained and trained elderly can increase the response of the cardiopulmonary without a significant reduction in peripheral ability to extract oxygen at the muscle level. Endurance exercise training in the elderly decreased resting and submaximal exercise heart rate (12), systolic and diastolic blood pressure (13). Long lasting aerobic exercise may increase left ventricular mass and chamber volume without wall thickening, a phenomenon known as eccentric cardiac hypertrophy. This adaptation augments stroke volume and thus maximum cardiac output without a significant change in maximum heart rate (14). The higher aerobic capacity in the trained elderly is related to increases in the abilities of cardiovascular factors following training and to the lesser extent to increases in muscle mitochondria concentration and capillarity (15). In addition to changes in stroke volume, peripheral oxygen extraction can increase modestly with training. This is due to increased capillary density in the trained skeletal muscles that facilitates very high levels of oxygen extraction across exercising skeletal muscle vascular beds (2). The efficiency of breathing is improved in the elderly following an endurance training program (16). These changes include reduction in lactic acid levels and increased maximal ventilation.

In summary, aerobic training induce significant cardiovascular and muscle improvements in the elderly leading to increase in maximal oxygen uptake. However, the improvement of the pulmonary system is less significance. This training mode of exercise elicit beneficial adaptations at the whole body, whole muscle, and muscle cell levels, particularly in older individuals, that carry important clinical implications for overall health and well-being. Based on these findings, it is suggested to elderly engaged in aerobic exercise training to perform at intensities of 60-75 % of their maximal reserved training heart rate. The ACSM guidelines for safety during training should be followed.

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