CONFERENCIA

The influence of exercise on cognition in older adults

Waneen W. Spirduso
The University of Texas at Austin

Conferencia de la Dra. Spirduso dictada en el III Congreso Internacional de Actividad Físico Deportiva para Mayores, celebrado en Málaga los días 12, 13 y 14 de marzo de 2009

Exercise directly benefits many types of cognition in older adults by enhancing four major areas of brain function: cerebrovascular function, cerebral neurotransmitter balance and function, neuroendocrine and autonomic tone, and brain morphology. Exercise also indirectly benefits cognition by affecting mediators of cognition, such as physical resources, disease states, and mental resources (Spirduso, Poon, & Chodzko-Zajko, 2008).

Direct Effects of Exercise on Cognition

Exercise has been shown to affect many physiological and genetic mechanisms. A frequent explanation is that physical activity has been associated with increased cerebral blood flow which provides increased oxygen and nutrient availability. Oxygen availability and utilization is increased, glucose regulation is improved, and neural function becomes more efficient. Exercise increases the synthesis of neurotrophic factors such as brain-derived neurotrophic factor (BDNF) which enhance neurological function and protect neurons from damage and disease. The regulation of neurotransmitters and neurohormones, essential to neuronal functioning, is enhanced by exercise (Holmes, 2006).

Exercise also has been associated with morphological changes in neuronal structure and neurogenesis (Black, Isaacs, Anderson, Alcontara, & Greenough, 1990). Voluntary running in rats produced increased neural cell proliferation and survival in parts of the brain involved in the running (van Praag, Kemperman, & Gage, 1999). Synaptic plasticity (adaptability of the connections among neurons) is also enhanced following physical activity. From magnetic resonance imaging (MRI) analyses, both grey and white matter brain tissue volume have been found to be greater in persons who exercise regularly compared to those who do not. Even more relevant, the areas that appear to be preserved by exercise are precisely those areas that reveal the greatest age-related declines (Colcomb, Erickson, Raz, et. al., 2003). These are all morphological mechanisms directly influenced by exercise. However, exercise also appears to substantially influence cognition indirectly by influencing mediators of cognition such as physical resources, mental resources, and by prevention or postponement of disease.

Indirect Effects of Exercise on Cognition

Indirect effects are realized through mediators, which are defined as a third variable that intervenes between two others, for example, exercise may be conducted outdoors, which exposes an individual to sunlight, which in turn influences the circadian rhythm, enhancing sleep and therefore enabling the brain to consolidate memories of events previously practiced or studied. Exercise might influence cognition *directly* by enhancing neurotransmitter function, but it also may affect cognition indirectly by facilitating better sleep regulation. These direct and indirect effects are shown in Figure 1.

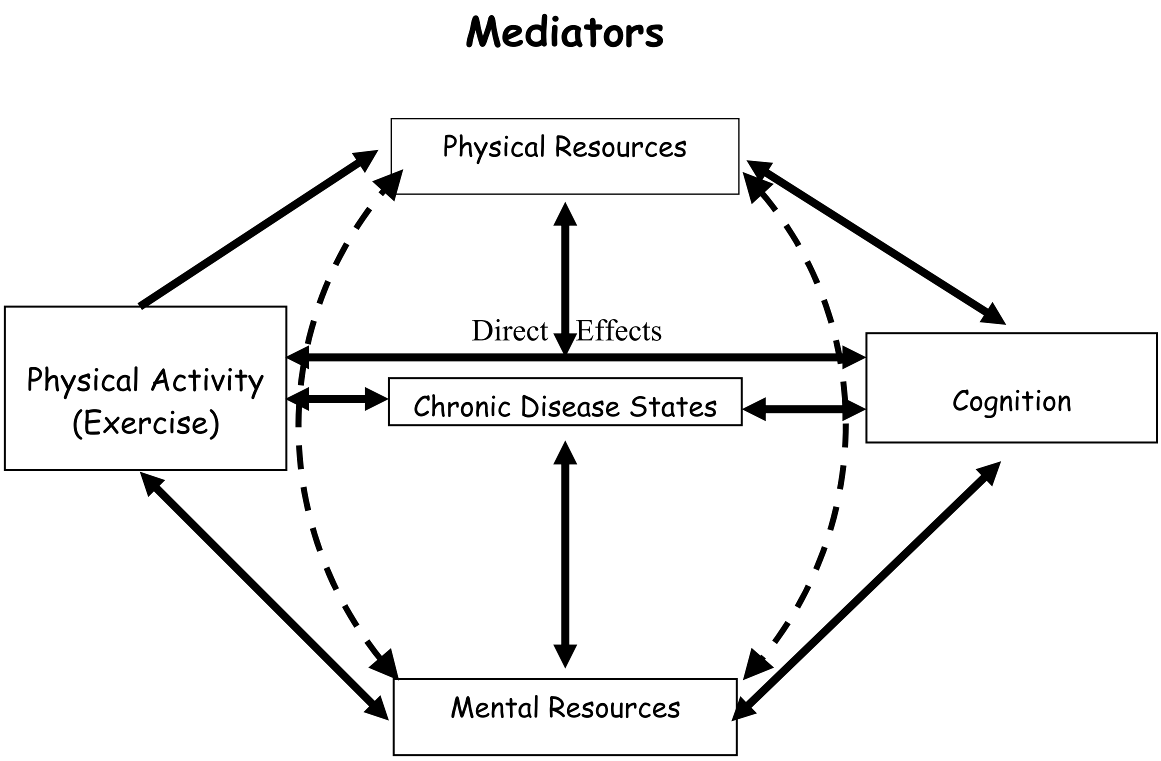

Figure 1. Model of direct and indirect and indirect effects of habitual exercise on cognition. From Exercise and its mediating effects on cognition (p. 4), by W.W. Spirduso, L.W. Poon, and W. Chodzko-Zajko, Champaign, IL: Human Kinetics. Copyright 2008 by Waneen W. Spirduso, Leonard W. Poon, and Wojtek Chodzko-Zajko (Modified with permission).

Some of the cognitive functions that have been studied with regard to exercise are attention, retrieval, executive function, problem solving, information processing speed, and learning. Executive function, which is responsible for planning and controlling sequences of action to attain a specified goal, appears to be particularly responsive to physical activity (Colcomb & Kramer, 2003). Executive function has been associated with frontal lobe activity of the brain, and there is some evidence that the frontal lobe is particularly vulnerable to age-related impairment in cerebrovascular circulation.

Physical Resources.

Effective cognitive activity depends on a healthy cerebral milieu, which is the physical environment (e.g., effective cerebral blood flow and efficient neurotransmitter function). A healthy physical brain environment maximizes the functional capacity of the brain to perform cognitive tasks and increases the energy level to enhance persons' performance state, i.e., their ability to use the functional capacity they have. Sleep effectiveness, mental energy, appetite, absence of pain, and drug and medication usage all either enhance or deplete individuals' physical resources.

Aging impairs deep sleep in a large proportion of older adults, but there is some evidence that exercise counteracts these impairments by enhancing sleep (Lopez, 2008). Some potential ways that exercise enhances sleep are by amerliorating depression, raising body temperature and by assisting in the control of circadian rhythm (Lopez, 2008). Exercise also has been found to decrease the reactivity of the hypothalamic-pituitary-adrenocortical axis (HPA) activity, a response which would enhance cognition (Vitiello, M.V., 2008).

Another physical resource necessary for effective cognition is mental energy. Mental energy may be depleted, so that mental fatigue ensues. Tomporowski (2008) proposes, based on energetics theory, that exercise may restore energetic resources and thus reduce mental fatigue.

Freedom from chronic pain, a frequent complaint of older adults, is another physical resource that must be present for cognition to function maximally. Older adults with conditions leading to chronic pain frequently complain that they cannot function cognitively when they are in substantial pain. A review of the literature on the effects of exercise in reducing pain showed that exercise has some value for some types of pain, particularly osteoarthritis. Thus, O'Connor (2006) proposed that chronic exercise might be beneficial, particularly for osteoarthritis patients, in not only relieving pain but in enhancing cognition.

Mental Resources.

These constructs involve the notions of positive states, such as arousal, attention, and motivation, and negative states, such as anxiety, stress, and depression. Arousal, attention, motivation, and feelings of self-efficacy enhance cognitive function, while anxiety, stress, and depression appear to impair cognitive function during performance. Exercise has been shown to have a positive effect on mental resources, which in turn mediate levels of chronic stress and depression, as well as enhancing levels of self-efficacy. In other words, exercise positively counteracts the negative effects of depression. As an example, depression has a negative effect on the performance states of mood, mental energy, and motivation, while exercise positively enhances these states (Bartholomew & Ciccolo, 2008). Indirect evidence is strong that cognitive declines in older adults who suffer from long term chronic stress may be ameliorated indirectly through exercise-induced management of stress (Berchtold, 2008).

Prevention or Postponement of Disease States.

A third indirect benefit of exercise is the prevention or postponement of disease states, such as hypertension, diabetes, cardiovascular and cerebrovascular disease, and chronic obstructive pulmonary disease (COPD). It has been known for many years that exercise plays a powerful role in the postponement or even prevention of these disease states, but only recently has it been fully appreciated how much the postponement or prevention of these diseases may affect cognition in older adults. Diabetes has long been associated with hypertension, and hypertension is associated with many types of impaired cognition. Thus, decreasing diabetic symptoms can lead to decreases in hypertension which in many patients assists in maintaining some types of cognitive function (Tanaka & Cortez-Cooper, 2008).

COPD is characterized by the persistent obstruction of airflow. Patients with COPD often display hypoxemia, which is also associated with impaired cognitive function. Researchers have proposed, using cross-sectional data, that exercise capacity is associated with psychomotor speed in patients with COPD (Emery, 2008). Thus exercise can reduce chronic disease-related loss of cognitive function by mediating these chronic diseases.

In summary, evidence has been accumulating in the last two decades that the beneficial effects of exercise in the postponement or prevention of many chronic diseases also indirectly enhances cognition in older adults. Less well understood has been the indirect effects of exercise, particularly habitual exercise, on preserving the physical and mental resources upon which cognition depends. Particularly important is the role that exercise may play in increasing the *functional capacity* or *reserve* of physical and mental resources necessary for several types of cognition in older adults. Increasing *functional capacity*, or *reserve* of physical resources and mental resources may also enhance the *performance state* of individuals, making them more effective in performing at their maximum level when they need to.

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