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Collaborative effects of diet and exercise on cognitive enhancement

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The brain has a remarkable capacity for plasticity, which can be enhanced by appropriate stimulation. Growing evidence indicates that aspects of lifestyle encountered in our daily routine can determine the capacity of the brain to fight diseases and react to challenges. For example, now we know that certain types of dietary factors, such as omega-3 fatty acids and curcumin, can stimulate molecular systems that serve synaptic function, while diets rich in saturated fats do the opposite. In turn, exercise, using similar mechanisms as healthy diets, displays healing effects on the brain such as counteracting the mental decline associated with age (Hillman et al., 2008) and facilitating functional recovery resulting from brain injury and disease (Griesbach et al., 2004). Diet and exercise are two noninvasive approaches that can be used to enhance neural repair (Chytrova et al., 2009). Omega 3 fatty acids and curcumin elevate levels of molecules important for synaptic plasticity such as brain-derived neurotrophic factor (BDNF), thus benefiting normal brain function and recovery events following brain insults. BDNF is a neurotrophin that, in addition to regulate the survival, growth, and differentiation of neurons during development (Zuccato and Cattaneo, 2009), stimulates synaptic and cognitive plasticity in the adult brain (Nagappan and Lu, 2005). BDNF modulates the efficacy of synaptic transmission and hippocampal long-term potentiation (Nagappan and Lu, 2005), and learning and memory in animals (Lu et al., 2008) and humans (Egan et al., 2003). Recent findings that BDNF is associated with energy homeostasis are offering new possibilities to understand the action of diet and exercise on the brain, as diet and exercise are intimately related to energy metabolism. For example, recent evidence indicates that exercise-induced BDNF influences hippocampal synaptic plasticity by modulating cellular energy metabolism(Gomez-Pinilla et al., 2008).

The action of select nutritional factors in the brain

Omega-3

One of the most important forms of omega-3 fatty acids, docosahexaenoic acid (DHA) is a key component of neuronal membranes at sites of signal transduction at the synapse, such that its action is vital to brain structure and function (Gomez-Pinilla, 2008). Evidence suggests that DHA serves to improve neuronal function by supporting synaptic membrane fluidity (Suzuki et al., 1998), and regulating gene expression and cell signaling (Salem et al., 2001). Because the inefficiency of mammals to produce DHA, consumption of dietary DHA is critical for proper neuronal function and promoting resistance to neurological disorders (Wu et al., 2004, Wu et al., 2007, Ma et al., 2009). The capacity of DHA to increase molecules associated with synaptic function such as the BDNF system and to normalize oxidative stress appear crucial for the healing effects of DHA after brain disorders (Wu et al., 2007, 2008).

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Curcumin

Curcumin is a major component of turmeric (*Curcuma longa*) and a commonly used spice in Indian meals. Substantial evidence from in vitro studies indicates that curcumin has antioxidant, anti-inflammatory activities (Menon and Sudheer, 2007). Curcumin as well as DHA has been shown to attenuate degenerative events in Alzheimer's disease mice model with advanced amyloid accumulation (Ma et al., 2009). In addition, curcumin dietary supplementation has been shown to reduce the effects of experimental concussive injury on cognitive function tasks involving the action of BDNF on synaptic plasticity (Wu et al., 2006). In addition, an important aspect of the healing power of curcumin seems to rely on its capacity to normalize energy homeostasis that is disrupted under trauma conditions (Sharma et al., 2009).

Collaborative effects of diet and exercise—Exercise has the capacity to enhance learning and memory under a variety of conditions, from counteracting the mental decline that comes with age (Hillman et al., 2008) to facilitating functional recovery after brain injury and disease (Vaynman and Gomez-Pinilla, 2005). Much like a healthy diet, physical activity can benefit neuronal function by increasing BDNF levels and reducing oxidative stress. More specifically, exercise plays an important role in the maintenance of the synaptic structure (Vaynman et al., 2004), axonal elongation (Molteni et al., 2004), and neurogenesis in the adult brain (van Praag et al., 1999). Exercise applied after experimental traumatic brain injury has also been shown to have beneficial effects but these effects seem to depend on the post-injury resting period and the severity of the injury(Griesbach et al., 2007).

Given the ability of exercise to augment BDNF levels, exercise may be an effective adjuvant therapy to balance the effects of dietary choices. In particular, it has been found in rats that exercise counteracts the decrease in hippocampal BDNF, synaptic plasticity, and cognitive function due to the consumption of a diet high in saturated-fat and sucrose (Molteni et al., 2004). In turn, the effects of the combined application of a healthy diet and exercise can promote enhanced beneficial effects on brain healing and plasticity than when either option is implemented by separate. For example, exercise is capable of boosting the healthy effects of omega-3 fatty acids on synaptic plasticity and cognition (Wu et al., 2008). The combination of experiences and various types of nutrients is a common attribute of our daily living. It is remarkable that new advances in molecular biology indicate that nutrients and experiences share common mechanisms that seem to have complementary effects on brain function. The challenge is how to take advantage of this capacity in order to boost brain health and plasticity as well as to counteract the source of neurological disorders.

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