Age Related Cognitive Decline: Why Exercise May be the Fountain of Youth

**Introduction**

 Improvements in healthcare and modern medicine have been steadily prolonging human life expectancy for many years. The oldest old, those aged 85 and older, represent the fastest growing segment of the population in the United States (Sumic, Michael, Carlson, Howieson, Kaye, 2007). The effects of aging are evident both physically and mentally. In fact, the human brain starts showing structural decline at thirty years of age (Colcombe et al., 2006). Cognitively, normal age related effects include decreases in working memory, perceptual speed, decision making, multi-task processing, accuracy, and response latency (Churchill et al., 2002; Bixby et al., 2007). One of the most dreaded consequences of aging is the onset of dementia, especially Alzheimer’s disease. Currently, there is no known treatment for dementia of any kind.

Recent research has proposed the idea of “successful aging” and that cognitive decline may not be an inevitable part of the aging process. The concept of “successful aging” largely focuses on identifying measures to prevent age-related cognitive decline in order to improve the quality of life for elderly citizens, to prolong independence, and to reduce the social and economic burdens on both families and the healthcare system (Larson et al., 2006). One specific preventative measure shown to delay the onset of dementia and slow the progression of Alzheimer’s disease is exercise. A multitude of recent studies have shown the beneficial effects of physical activity on improving and delaying age-related cognitive decline. Physical activity in elderly individuals results in and maintains a more efficient, plastic, and adaptive brain (Colcombe et al., 2004). The purpose of this paper is to review current findings on the neurological effects of physical activity in elderly populations and to evaluate the practical implementation of this research.

**Neurological Effects**

*Brain Volume*

 With age, the density of brain tissue decreases. Thinning of the tissue in the brain is related to a decrease in overall volume, which is indicative of dementia and Alzheimer’s disease. Exercise and physical activity have been shown to not only spare brain volume in healthy older adults, but to actually increase brain volume as well. Colcombe et al. (2006) conducted a randomized study of elderly, healthy adults and compared an aerobic exercise group to an anaerobic stretching and toning control group. Through brain imaging, they found the aerobic exercise group showed increased brain volume. Even individuals who had previously sedentary lifestyles showed increased brain volume. This finding demonstrates the protective role physical activity exhibits in sparing brain volume in aging adults.

 Colcombe et al. (2006) found the greatest effects were observed in the frontal and temporal lobes of the brain, a widely corroborated finding (Colcombe et al., 2004; Barnes, Yaffe, Satariano, Tager, 2003; Williamson et al., 2009; Rolland, Abellan van Kan, Vellas, 2008). Because these regions of the brain show the fastest rate of age related cognitive decline (Colcombe et al., 2004), there is more opportunity for exercise to be of benefit in these regions. However, the extent of volume loss brings to attention a significant limitation of all studies in this field. A major potential confounder for determining the relationship between physical activity and cognitive decline is education level and IQ score; both contribute to overall higher brain tissue density and volume (Bixby et al., 2007). Education level is tied to greater density of neurons and synaptic connections due to repeated cognitive stimulation and more experiences across the lifetime. Controlling for these confounders is essential to establishing the effects of physical activity alone on cognitive decline and the delay of dementia.

In a study conducted by Bixby et al. (2007) in which education and IQ score were rigorously controlled for, a statistically significant positive association still remained for the protective effects of physical activity on cognitive functioning. This attests to the unique role exercise has in the preservation of cognitive function. Furthermore, the MoVIES Project targeted studies collecting data on people not usually included in scientific studies, particularly people from rural areas of the country. One such study by Lytle et al. (2004) examined exercise and cognitive decline in an atypical sample population consisting of 1,146 men and women ages 65 and older who lived in rural, blue collar counties in Pennsylvania. Collectively, this sample had lower baseline levels of physical activity, was of lower socioeconomic status, had completed fewer years of formal education, had lower IQ scores, and was more likely to report memory problems at a relatively younger age. After controlling for potential confounders such as IQ score and education level, those individuals who reported higher levels of physical activity at baseline were less likely to develop dementia of any kind two years later. Taken together, these studies confirm the sparing effect exercise has on brain tissue and volume in preserving cognitive function in older adults, especially in the frontal and temporal lobes. This suggests that exercise specifically benefits target regions of the brain that preserve cognitive functioning.

*Principle of Specificity*

Another line of research investigating specific neurological adaptations from physical activity shows the frontal and temporal lobes of the brain are indeed most affected. Specific regions of the brain are responsible for particular functions. For example, executive functioning, the highest order of cognition, includes multi-tasking, planning, working memory, and behavior modification in novel situations. Executive functioning is carried out primarily by the frontal lobes and secondarily by the temporal lobes. Consequently, these are the areas most impacted by degenerative diseases such as dementia. Because the frontal and temporal lobes exhibit the greatest rate of age related decline, it is believed that exercise exerts the greatest influence in these regions, complying with the principle of specificity (Bixby et al., 2007). In the field of exercise physiology, the principle of specificity states that muscles make specific adaptations to certain imposed physical demands. This principle also applies to the brain in its capacity as a muscle now that it has been shown that exercise robustly impacts the brain. Unlike previously assumed, exercise does not affect the brain globally. On universally used tests of cognition, scores improved most on tests engaging executive task functioning such as the Stroop Color, Word, and Interference Tests, the Mini Mental State Examination, and Digit Symbol Coding tests (Bixby et al., 2007; Barnes et al., 2003; Williamson et al., 2009; Sumic et al., 2007; Ravaglia et al., 2007; Laurin, Verreault, Lindsay, MacPherson, Rockwood, 2001). Interestingly, in sample populations that contained more women than men, it was found that the magnitude of the effect of physical activity was much greater (Sumic et al., 2007; Rolland et al., 2008; Laurin et al., 2001). A pioneering study (Yaffe, Barnes, Nevitt, Lui, Covinsky, 2001) investigating cognition and physical activity used an all female sample and found the impact of physical activity to be much greater than in mixed samples. The gender discrepancy in effect of physical activity on cognition can also be explained by specificity. The volume of the frontal lobe tissue decreases more rapidly in women than men, meaning there is a greater opportunity for exercise to be of benefit in women, thus a greater effect magnitude. The means by which exercise affects the frontal and temporal lobes is discussed in terms of cerebral blood flow and neural integrity.

*Angiogenesis and Neurogenesis*

Physical activity induces angiogenesis in as little as three months post work out (Rolland et al., 2010). Angiogenesis is the birth of new capillaries in the brain. An increased density of blood vessels increases cerebral blood flow which functional MRIs show is a direct determinant of cognitive processing. Aerobic exercise only (not anaerobic exercises such as stretching and toning) will induce a biological benefit. This is because heart-pumping aerobic exercise releases a growth factor that generates new blood vessels, not only in the brain, but the body. This finding relates measures of cardiovascular fitness to be used as indicators of cognitive function in aging adults (Barnes et al., 2003).

Increased cerebral blood flow from angiogenesis induced by physical activity contributes to the birth of new neurons, or neurogenesis (Rolland et al., 2008). A greater density of neurons and dendritic connections increases brain volume and offsets dementia. The ability of the brain to form new neurons and connections is referred to as plasticity. Recent studies have confirmed the plasticity of the brain over the course of a lifetime (Rolland et al., 2008). It was previously assumed that the brain formed all dendritic connections during a discreet critical period at a young age and after that no new connections formed. The recent discovery that physical activity actually makes the brain more plastic is revolutionary and key in understanding the course of Alzheimer’s disease and dementia. Physical activity is also responsible for triggering the release of various growth factors, specifically brain derived neurotrophic factor (BDNF) that maintains neural integrity (Bixby et al., 2007). Where these neurons grow is uniquely exercise specific. A recent review by Churchill et al. (2002) reported that “some aspect of the activity that is related to skill acquisition…is an essential feature necessary to induce synaptic modification.” This means that exercise and physical activity offer advantageous brain modification that is unrelated to IQ score or education level. Knowing exercise induces the birth of neurons while learning enhances their survival, makes the case for a cross disciplinary approach to successful aging: one that combines the traditional cross-word puzzle approach with maintaining or beginning an exercise regimen.

**Practical Implementation**

 As the average life expectancy continues to be extended, quality of life for older citizens is an increasingly pressing issue facing families and the healthcare system. As the literature has shown so far, individuals with higher levels of physical activity at baseline decreased their chances of developing dementia of any type by as much as 50% in studies that followed up years later (Laurin et al., 2001). This is a promising finding, but it begs the question of the practical implementation of this research into retirement communities, assisted living facilities, nursing homes, and current treatment practices for dementia. If people did not exercise regularly throughout their lives prior to showing early symptoms of dementia, does physical activity still have an effect? In a study conducted by Lautenschlager et al.(2008) participants were included who either self-reported memory problems, or who scored below a 27 on the 30 point Mini Mental State Examination, a universally accepted measure of cognitive ability and mental state for elderly age groups. This study differed from the others in the fact that it did include subjects with memory impairment; the majority of studies excluded unhealthy or otherwise cognitively impaired subjects. Results from the study showed that individuals with early symptoms of dementia improved on cognitive tests of executive function. Therefore, incorporating some type of exercise regimen into retirement homes and communities would be beneficial to residents.

 Moreover, aerobic exercise would be convenient to incorporate for elderly people. Taking a walk is cost-effective, as well. Residents of nursing homes tend to be left unattended and unengaged for long periods of time. Cognitive stimulation is critical to preventing the onset of dementia and to preserving cognitive function. Cognitive stimulation and social interaction are secondary and tertiary benefits of engaging in physical activity that are also essential for an improved quality of life for elderly residents.

**Conclusion**

Across many of the studies reviewed in this paper, several of the same limitations presented themselves. One such limitation was an effect difference in forced versus voluntary exercise. This is a significant limitation with serious practical implications if forcing previously sedentary people to begin exercising does not yield the same cognitive benefits. In animal studies with rats, voluntary exercise as a result of a complex environment yielded a greater biological benefit than forced exercise on a wheel (Rolland et al., 2008). It has not been evaluated if this applies to humans. Defining a biological benefit is another shortcoming. It has not been tested if there is a certain threshold of physical activity that yields a biological benefit (Rolland et al., 2010). Due to the nature of these studies, defining parameters for measures is tedious, but crucial to direct future research. For example, determining an activity threshold and even defining “physical activity” is lacking (Rolland, Abellan van Kan, Vellas, 2010). The literature was split regarding the definition of physical activity. Some studies defined physical activity as 30 minutes or greater of aerobic exercise, four or more a week (Ravaglia et al., 2007). However, other studies used the Yale Physical Activity Scale (YPAS) as a measure of baseline activity and this scale includes activities of daily living (ADL) such as standing, household chores, and stair climbing (Bixby et al., 2007). Because the target age group is elderly citizens, including ADLs may be more appropriate.

 A major limitation that will surely be the focus of future research involves discerning the timeline of a decline in activity level and the onset of dementia. For example, is inactivity a result of normal aging, or an early symptom of dementia? This question cannot be answered with the current research that is short term relative to the years it takes for symptoms of dementia to be diagnosed. Also, more studies will have to control for lifestyle factors to determine if physical activity induces better cognitive functioning, or if people who exercise more tend to already engage in healthier lifestyle habits such as not smoking, better nutrition, and lower body mass index (Churchill et al., 2002).

 The benefits of physical activity in delaying the onset of dementia and preserving cognitive function will be an important new factor in the treatment of dementia and successful aging. As the expected lifespan increases to unprecedented ages, ensuring the quality of life for the elderly will be of the utmost importance and exercise can be a convenient and cost-effective solution. The benefits of physical activity that preserve cognitive functioning include sparing brain volume in the frontal and temporal lobes that mediate executive functions. Physical activity also induces angiogenesis and neurogenesis, which is the birth of new blood vessels and new neurons, respectively. This finding suggests the plasticity of the human brain persists over a lifetime and preserving, protecting, and stimulating the brain through physical activity is crucial to successful aging.

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