Exercise and cognition in older adults: is there a role for resistance training programmes?

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ABSTRACT

In recent years, there has been a strong interest in physical activity as a primary behavioural prevention strategy against cognitive decline. A number of large prospective cohort studies have highlighted the protective role of regular physical activity in lowering the risk of cognitive impairment and dementia. Most prospective intervention studies of exercise and cognition to date have focused on aerobic-based exercise training. These studies highlight that aerobic-based exercise training enhances both brain structure and function. However, it has been suggested that other types of exercise training, such as resistance training, may also benefit cognition. The purpose of this brief review is to examine the evidence regarding resistance training and cognitive benefits. Three recent randomised exercise trials involving resistance training among seniors provide evidence that resistance training may have cognitive benefits. Resistance training may prevent cognitive decline among seniors via mechanisms involving insulin-like growth factor I and homocysteine. A side benefit of resistance training, albeit a very important one, is its established role in reducing morbidity among seniors. Resistance training specifically moderates the development of sarcopenia. The multifactorial deleterious sequelae of sarcopenia include increased falls and fracture risk as well as physical disability. Thus, clinicians should consider encouraging their clients to undertake both aerobic-based exercise training and resistance training not only for "physical health" but also because of the almost certain benefits for "brain health".

Cognition can be defined as "the intellectual or mental process whereby an organism becomes aware of or obtains knowledge."[1] Human aging is associated with declining cognition and increasing risk of dementia. Mechanisms that underlie age-related decline in brain function include reduced volume of the cerebral white matter,[2] declines in the concentration, synthesis and number of receptor sites for neurotransmitters,[3 4] and pathological changes such as cerebral white matter lesions.[5–8]

The economic impact of cognitive impairment is substantial. In 2000, Alzheimer's disease and other types of dementias were the third most expensive healthcare condition in the USA, preceded by only heart disease and cancer.[9] Annual costs for Alzheimer's disease and other dementias were estimated at 100 billion dollars in the USA in 1997.[9] Strategies that would prevent the onset or progression of cognitive impairment among seniors would have enormous societal value. Brookmeyer and colleagues[10] estimated that, if current interventions could delay both the onset and progression of dementia by a modest 1 year, there would be nearly 9.2 million fewer cases of disease in 2050.

Physical activity has been widely promoted as a strategy for healthy aging, as it can reduce the incidence of cancer, diabetes and heart disease.[11] In recent years, there has been a strong interest in physical activity as a primary behavioural prevention strategy against cognitive decline. As highlighted in the review of Erickson and Kramer[12] in this special issue of *British Journal of Sports Medicine*, physical activity provides clear benefits for cognition among seniors. These neuroscientists contend that "physical activity is an inexpensive treatment that could have substantial preventative and restorative properties for cognitive and brain function."[13] Certainly, a number of large prospective cohort studies have highlighted the protective role of regular physical activity in lowering the risk of cognitive impairment and dementia.[14–16] Most prospective intervention studies of exercise and cognition to date have focused on aerobic-based exercise training—both in animals[17–20] and humans.[21–23] These studies highlight that aerobic-based exercise training enhances both brain structure and function.[17–19 21–23] However, it has been suggested that other types of exercise training, such as resistance training, may also benefit cognition.[24] The purpose of this brief review is to examine the evidence regarding resistance training and cognitive benefits.

RESISTANCE TRAINING AND COGNITIVE OUTCOMES IN HUMANS

Although resistance training has a broad range of systemic benefits for older adults,[25–29] very few studies have specifically focused on its role in promoting cognitive health among seniors. Until recently, most exercise trials that examined the potential effect of resistance training on cognition in humans were limited by small sample sizes (eg, 13 and 23 participants per experimental group) and short intervention periods (eg, 8 and 16 weeks).[30 31]

Possible mechanisms whereby resistance training may prevent cognitive decline

Studies with intermediate outcome measures from both human trials and laboratory experiments justify the study of resistance training and cognition. In humans, resistance training reduced serum homocysteine[32] and increased concentrations of insulin-like growth factor I (IGF-I).[33 34] Increased homocysteine concentrations are associated with impaired cognitive performance,[35] Alzheimer's disease[36] and cerebral white matter lesions.[37] Specifically, in a 2-year prospective study, raised

homocysteine impaired neuropsychological functioning in otherwise cognitively intact seniors.[38] In rat models, raised concentrations of homocysteine are neurotoxic.[39] In contrast, IGF-I promotes neuronal growth, survival and differentiation and improves cognitive performance.[40] Thus, resistance training may prevent cognitive decline among seniors via mechanisms involving IGF-I and homocysteine.

Recent randomised trials of resistance training among seniors

Cassilhas and coworkers[34] showed that 6 months of either moderate-intensity or high-intensity resistance training significantly improved cognitive performance on standard neuropsychological tests of memory (short and long term) and verbal reasoning among senior men. They also found that serum IGF-I concentrations were higher in the resistance training groups than in the control group. Recently, Liu-Ambrose and colleagues[41] showed that an individualised home-based programme of balance and strength retraining, known as the Otago Exercise Program,[42] significantly improved executive functioning after 6 months among seniors aged 70 years and older with a recent history of falls. The finding of this study is notable given that many have hypothesised that the cognitive and neural benefits of exercise must occur within the context of social engagement for exercise to be effective.[43] Details of the Otago Exercise Program are illustrated and detailed in a dedicated publication.[44] Briefly, basic exercises for strength and balance retraining were performed for about 20 min/day, three times a week. Adding support to these data, Brown and colleagues[45] showed that a 12-month group-based programme of strength and balance training exercises significantly improved fluid intelligence among seniors residing in retirement villages.

Thus, there is evidence to support the hypothesis that resistance training (and balance training) may have cognitive benefits among seniors. We emphasise that resistance training may be of particular importance to senior women, as they are at greater risk of falls and fractures than senior men. However, more research is needed to clearly define the role of resistance training in the prevention of cognitive decline. Specifically, studies are needed to: (1) examine whether resistance training has similar benefits on brain function and structure to those previously shown with aerobic-based exercise training[21–23]; (2) examine the variables of resistance training (ie, frequency, duration and loading intensity) for maximum cognitive benefits; (3) examine whether the cognitive benefits of resistance training are limited to specific cognitive processes or general across multiple cognitive domains; (4) compare the effect of aerobic-based exercise training and resistance training on cognitive and neural plasticity. Certainly, animal studies will be essential to our understanding of the underlying mechanisms by which resistance training promotes cognitive and neural plasticity. However, for such animal studies to be conducted, methods to strength train the animals voluntarily must be developed. As highlighted by Erickson and Kramer,[12] there is an urgent need for research to investigate the effects of multiple types of exercise training on cognition. It is only with better understanding that we can design and deliver optimal exercise interventions to ward off cognitive decline and its associated morbidity in an aging population that is increasing yearly.

Additional benefits of resistance training for seniors

A very important benefit of resistance training for cognitive function is its role in reducing other morbidities among seniors. Resistance training provides a broad range of systemic benefits,[25–29] including moderating the development of sarcopenia—something that aerobic-based exercise training does not do. The multifactorial deleterious sequelae of sarcopenia include increased falls and fracture risk as well as physical disability.

CLINICAL IMPLICATIONS OF CURRENT DATA ON RESISTANCE TRAINING AND COGNITION

What are the implications of these few studies of resistance training and brain function for the clinical readership of the *British Journal of Sports Medicine*? These findings reinforce American College of Sports Medicine (ACSM) guidelines that encourage resistance training at least twice weekly for healthy seniors.[46] A meta-analysis found that combined programmes of aerobic-based exercise training exercises and resistance training exercises had a greater positive effect on cognition than programmes of aerobic-based exercise training only.[24] Thus, clinicians should consider encouraging patients to undertake both aerobic-based exercise training and resistance training not only for "physical health" but also because of the almost certain benefits for "brain health". Many community and fitness centres have trained staff who can assist seniors to safely initiate and engage in a resistance training programme. People interested in taking up resistance training should consult their family doctor and may wish to review the ACSM position stands: exercise and physical activity in older adults[47] and progression models in resistance training in healthy adults.[46]

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