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Resistance Exercise to Improve Cognitive Function

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ABSTRACT

EVIDENCE IS EMERGING THAT RESISTANCE EXERCISE (RE) CAN IMPROVE COGNITIVE FUNCTION AND THE QUALITY OF LIFE IN SENIORS. THIS ARTICLE DEMONSTRATES TO THE EXERCISE PROFESSIONAL THAT BOTH ACUTE AND CHRONIC RE HAS A POTENTIAL BENEFICIAL EFFECT ON COGNITIVE FUNCTION IN MIDDLE-AGED AND OLDER MALES AND FEMALES.

INTRODUCTION

The aging process brings both physical and mental challenges across the globe. Exercise professionals (EPs) are in a unique position to help individuals to minimize the deleterious effects of the dynamic and progressive process of aging. EPs suggest many strategies to clients to positively influence their health and fitness, such as controlling stress, eating healthy, getting enough sleep, having a positive outlook on life, staying engaged in their community, avoiding tobacco use, and limiting alcohol consumption. Resistance exercise (RE) is a key component because skeletal muscle function (i.e., strength) is critical for healthy survival and daily function.

The American College of Sports Medicine (29) identifies that sarcopenia (age-related loss of muscle) limits muscle function, with 25% of maximal force capacity being lost by the age of 65 years and as much as 40% over a lifetime. A significant compromise in muscle strength may necessitate institutionalized care because skeletal muscles are used for interaction with an individual's daily life, such as dressing, rising from a chair, feeding, shopping for food, or personal hygiene. Skeletal disuse, unloading, or inactivity can occur in otherwise healthy individuals as a result of injury or illness, and signs of muscle loss and muscle strength are evident after only a few days of disuse (25).

Throughout a person's lifespan, the accumulation of short periods, typically less than 10 days, of muscle disuse atrophy are likely contributors to age-related sarcopenia (35). Bed rest associated with hospitalization for a disease poses a threat to muscle tissue and functional capacity (13). For example, reduced muscle activity can lead to reductions in strength up 3–6% per day in the first week alone. Also, 10 days of immobilization in healthy individuals may cause up to 40% decrease of initial 1 repetition maximum (1RM) (26). Therefore, maintaining and improving strength during and after prolonged bed rest and immobilization are keys to preventing the loss of function in activities of daily living.

Fiatarone et al. (14) conducted a high-intensity progressive RE in nonagenarians. This study showed that elderly men and women, aged 86–96 years, benefited from weight training to improve strength and functional mobility (14). Another larger trial by Fiatarone et al. (15) of frail nursing home men and women residents with ages ranging from 76 to 98 years found that high-intensity RE is a feasible and an effective means of counteracting muscle weakness and physical frailty in elderly individuals.

Aside from the loss of physical independence, impairment of cognitive function (also known as executive function) can lead to individuals experiencing difficulties with activities of daily living, such as eating, bathing, dressing, toileting, and walking. A decline or impairment of cognitive function can also result in reduced quality of life and problems with social engagement, work-related tasks, managing finances, driving skills, shopping, and using communication devices such as a telephone (22). Cognition can be defined as thinking skills, language use, perception, calculation, awareness, memory, reasoning, judgment, learning, intellect, social skills, and imagination (34).

To help reduce the decline in cognitive function and prevent the decrease in executive function experienced during the aging process, aerobic exercise and RE have been investigated. Several meta-analyses studies have confirmed the selective benefits of exercise and fitness on cognitive function (7,11,19,21). Specific studies of aerobic

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exercise show that there are beneficial effects on cognitive function (10,20). RE has been well established as a safe and effective modality for improving muscle strength, power, and functional mobility and reducing weakness in elderly individuals (1,9). More studies are focusing on RE as a tool to improve cognitive performance (3,4,6,8,18,24,27).

This article briefly reviews the evidence for RE for improving cognitive function. The EP will learn the feasibility of long-term, intermediate-term, and short-term RE as a viable form of physical activity to enhance cognitive function in aging adults.

LONG-TERM RESISTANCE EXERCISE

Long-term RE, as discussed in this article, is defined as a program that lasts 24 weeks or longer. Cassilhas et al. (3) conducted a 24-week study to assess the impact of high-intensity (i.e., 80% of 1RM) and moderate-intensity (i.e., 50% of 1RM) RE on cognitive function in 62 sedentary men aged 65 to 75 years. The findings showed improvement for the experimental groups (i.e., high-intensity and moderate-intensity groups exercising 3 times a week) compared with the control group (i.e., once a week to warm-up and stretching without overload) for the 1RM tests, mood profile, and quality-of-life scores (i.e., based on the Medical Outcomes Study Questionnaire SF-36 questionnaire, Geriatric Depression Scale, and the Profile of Mood Sates scale), and on cognitive performance tests and insulin-like growth factor-1 (IGF-1). Other authors have shown that higher peripheral concentrations of IGF-1 might account for increased cognitive performance (2,33). The authors of this study concluded that RE had a positive impact on cognitive function in the elderly in both the moderate- and high-intensity groups (3).

Liu-Ambrose et al. (24) conducted a 52-week study to determine the effects of once-weekly or twice-weekly RE on executive cognitive function of 155 women aged 65 to 75 years. The results showed that RE performed as little as once per week can significantly benefit executive function in women. However, the authors pointed out that this must be weighed against the fact that the once-weekly RE group had higher musculoskeletal adverse events. The authors also reported an unexpected result of reduced brain volume for both RE groups. They cautiously indicated that this finding may be because of reduced beta-amyloid load as reported in other studies investigating Alzheimer's disease (17,32).

INTERMEDIATE-TERM RESISTANCE EXERCISE

Intermediate-term RE, as defined in this article, is exercise consisting of greater than 3 sessions and less than 24 weeks in duration. Fragala et al. (18) conducted a 6-week study of 25 healthy men and women aged 60 years or older to evaluate the effects of RE on spatial awareness and the visual and motor aspects of reaction time. The authors identify spatial awareness as a component of cognitive function and indicate that reaction time is important for allowing a person to perceive their environment and react in a proper manner to avoid accidents.

The study had the older adults undergo 2 RE sessions per week for 6 weeks, with each full-body session consisting of 7 or 8 lower- and upper-body exercises. Each exercise session used 3 sets for every exercise and repetitions varied from 8 to 15 repetitions, with the load being adjusted according to a moderate rating (i.e., 5 or 6 on a 0–10 scale) on the OMNI (i.e., contraction of the word omnibus, meaning a scale having broadly generalizable properties) scale of perceived exertion for RE. The authors indicated that mechanisms of how RE may improve spatial awareness are unknown. They concluded that RE may be an effective way to preserve or improve spatial awareness and visual and physical reaction time in older individuals.

Ozkaya et al. (27) conducted a 9-week study of 36 healthy men and women aged 60 to 80 years to determine the effects of aerobic training and strength training on cognitive performance. The aerobic training group exercised at an intensity of 70% of heart rate (HR) reserve 3 days per week, starting at 20 minutes for the first session and progressing to 50 minutes of walking by the third week. The strength training group performed 1 set of 12 repetitions of 7 exercise stations in the first week and 3 sets by the second week, starting at 60% of 1RM and adjusted by 5% every 2 weeks until 80% of 1RM was reached. The authors concluded that their study suggests that strength training may facilitate effects on early information processing and cognition.

SHORT-TERM RESISTANCE EXERCISE

Short-term RE, as defined in this article, is exercise consisting of 3 or fewer sessions in duration. Chang et al. (8) conducted a short-term study of men and women to evaluate the effects of brief RE on cognition. The purpose of the study was to assess the acute effects of RE on cognitive function in 30 men and women aged 55 to 70 years. The subjects were tested on 3 separate days and each group received the treatment in a different order to minimize practice and order effects. The subjects performed the 7 RE for 2 sets of 10 repetitions of 70% of 10RM for each exercise in approximately 20–25 minutes after a 10-minute warm-up.

The authors of this acute training study indicated that their behavioral measurements did not permit direct conclusions that physiological mechanisms (e.g., HR and catecholamine levels) were responsible for cognitive function changes resulting from acute exercise as indicated in another study (5). The authors provided some plausible mechanisms (i.e., exercise-induced arousal as indicated by catecholamine level and HR, and also plasma brain-derived neurotrophic factor) for the relationship between cognitive function and exercise; however, they indicated that further research is

needed to understand how and why RE influences cognitive function. The authors of this study concluded that acute RE had beneficial effects on multiple executive cognitive functions in late middle-aged adults and seniors (8).

Chang et al. (6) conducted a short-term study of men and women aged 55 to 70 years, where the subjects were seen for 3 sessions separated by at least 48 hours. The purpose of the study was to measure the effects of acute whole-body RE on late middle-aged adults' performance on a neuropsychological assessment (i.e., Tower of London task used to measure planning and working memory, which is a component of executive function). The subjects performed the 7 REs for 2 sets of 10 repetitions of 70% of 10RM for each exercise in approximately 20 minutes after a 10-minute warm-up. The authors indicated that neurohormonal mechanisms (i.e., IGF-1) may explain the benefits of RE on cognition as seen in this study. The authors concluded that RE alters arousal and improves cognitive performance by affecting anticipation, motor planning, and orienting.

Finally, another short-term study shows that RE improves executive cognitive function. Chang and Etnier (4) conducted a short-term study of men and women, where the subjects were seen for 2 visits. The purpose of the study was to examine the effects of an acute bout of RE on cognitive functions in 41 men and women aged 35 to 65 years. The subjects performed the 6 REs for 2 sets of 10 repetitions of 75% of 1RM for each exercise in approximately 45 minutes.

The authors reported that acute RE was effective in increasing HR in this study (4). Therefore, the authors indicated that the results were consistent with another acute aerobic exercise study (20) showing that exercise-induced physiological arousal (as measured by HR) may be a potential mechanism for improving cognitive function. The authors concluded that an acute bout of RE had beneficial effects on cognitive function in middle-aged adults. Further research is needed to determine if increased HR, which may lead to increased circulation to the brain or increased plasma proteins, such as catecholamines, is a potential mechanism for improvements in cognitive function. Alternatively, are the mechanisms for improvement because of other additional biological variables or psychological factors not identified in this article?

COGNITIVE IMPROVEMENT MECHANISMS

Although we do not know how RE enhances cognition in the elderly, the research does give us some possible mechanisms. Those mechanisms given in the research are outlined below:

- Cassilhas et al. (3) proposed that chronic RE increases blood flow to the brain, resulting in transportation of nutrients and oxygen to the central nervous system. These findings were also observed in previous research (27,28).
- Increased blood viscosity has been negatively correlated with cognitive performance (31). Even though Cassilhas et al. (3) did not attribute blood viscosity improvements to their study, they hypothesized that aerobic training in general leads to improved blood flow, and therefore, reduced blood viscosity could lead to improved cognitive performance.
- Cassilhas et al. (3) showed that chronic RE increases IGF-1 serum concentrations and indicated that IGF-1 is involved in modulation of brain-derived molecules. IGF-1 also promotes neuronal growth, survival, and differentiation and improves cognitive performance (2,12).
- Cassilhas et al. (3) also proposed that exercise in general could boost activity of antioxidant enzymes and thus enhance oxidative damage repair (30).
- Liu-Ambrose et al. (24) proposed that reduced beta-amyloid load could be a factor in improved cognitive function as seen in other studies (17,32).
- Chang and Etnier (4) have hypothesized that exercise-induced physiological arousal (as measured by increased HR) may be a mechanism for the benefits of RE on cognitive function.
- Chang et al. (8) indicated that changes in arousal and specific physiological mechanisms might explain the improvements seen in their study.
- Chang et al. (6) indicated that neurohormonal mechanisms (i.e., IGF-1) may explain the benefits of RE on cognition as seen in this study.
- Fragala et al. (18) indicated that mechanisms of how RE may improve spatial awareness are unknown; however, they discussed how other research showed the mediating role (i.e., a mediator is any substance that transmits information between 2 cells, tissues, or organs) of circulating growth factors, neurotrophins in neural adaptations, and how exercise affects brain function by increasing cerebral blood flow, improving transport, and in the use of nutrients, neurotransmission, and neurogenesis (34).
- Ozkaya et al. (27) hypothesized that strength training may cause neurobiological changes in neurotransmitter functioning, cerebral blood flow, or increased cell complexity in different brain regions.

This research provides some possible mechanisms for cognitive improvement with RE; however, further research is needed to identify the exact mechanisms that may help an EP in designing RE programs. For example, improvements in cognitive function as measured by various tests may be because of the group setting and socialization aspect of RE. Moreover, individuals participating in RE may have a higher sense of achievement and thus perform better on tests (23). Other authors indicate that improvement in cognition may be because of the fact that individuals inexperienced in RE may be obtaining a cognitive stimulus by having to recall exercise names, machine settings, principles of progression, and the muscle groups

used (16). Ozkaya et al. (27) also indicated that simply participating in group activities, which requires following instructors' orders and sharing of information, may have contributed to improved cognitive function. Or, are improvements in cognitive function because of other biological and physiological factors not stated in this review?

PRACTICAL APPLICATIONS

Even though aging is a progressive and dynamic process, RE has been shown to help and even prevent some of the observed negative changes. EPs play a key role in designing simple and effective RE programs for all age groups, especially seniors, to help improve and maintain cognitive function.

The following are practical guidelines for RE consistent with recommendations outlined by the American College of Sports Medicine for older adults (29). When prescribing RE for older individuals to improve cognitive function and also physical function, consider starting with light-intensity exercise (i.e., 40–50% 1RM) to moderate-intensity exercise (i.e., 60–70% 1RM) and gradually progress to higher intensities only if the individual can tolerate higher intensities from a physiological and psychological standpoint. Some individuals may have preexisting injuries that may necessitate lower intensities or some individuals may simply avoid RE or any type of exercise altogether if the intensity is too high. Therefore, it is better to have individuals exercise at some intensity that they can tolerate rather than to avoid RE all together.

EPs should consider designing RE programs that exercise the full body in one session using 1–2 sets of 10–15 repetitions covering the major muscle groups with 7–10 exercises at least 2 times per week. The program should include a warm-up and cool-down period, and the entire RE should last approximately 30–45 minutes, or longer, as tolerated by the individual. Based on the review of studies in this article, RE should be recommended as an integral part of a weekly fitness program across all age groups to help improve and maintain mental and physical function across an individual's lifespan.

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