




Review Article

A Comparative Study of the Effects of Aerobic and Resistance Training on Physical and Cognitive Health in Older Adults

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ABSTRACT

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As the global population ages, maintaining health and functionality in older adults has become a key public health priority. Exercise is widely recognized as a powerful intervention to enhance physical and mental health, reduce the risk of chronic diseases, and improve the quality of life in older adults. Among the various types of physical activity, aerobic and resistance exercises are two of the most frequently recommended for elderly populations. This article provides a detailed comparison of these two forms of exercise, examining their effects on cardiovascular health, musculoskeletal integrity, cognitive function, metabolic health, psychological well-being, and overall quality of life in older adults.

Keywords: Aerobic Training, Resistance Training, Aged

Cardiovascular health: aerobic exercise benefits

Cardiovascular disease remains the leading cause of mortality in older adults, and aerobic exercise is consistently recommended as a preventive measure (1). Aerobic exercises such as walking, cycling, swimming, and dancing involve continuous, rhythmic activities that elevate heart rate and improve cardiovascular fitness (2, 3). Aerobic exercise encompasses various types of physical activities that elevate both heart rate and respiratory volume, thereby fulfilling the oxygen demands of engaged muscles. In contrast to pharmacological interventions, aerobic exercise is generally more accessible and tends to have a lower incidence of adverse effects (4). Aerobic exercise is highly effective in lowering both systolic and diastolic blood pressure in older adults, contributing to a reduced risk of hypertension and related cardiovascular conditions (5). Additionally, aerobic exercise improves lipid profiles by increasing high-density lipoprotein levels (4, 6). The effect of aerobic exercise on low-density lipoprotein cholesterol levels in humans shows considerable variability, and in this regard, some studies report conflicting results (6). According to a study by Kodama et al., elderly individuals who engaged in regular aerobic activity exhibited significant improvements in their cholesterol levels,

which is crucial for preventing atherosclerosis and other cardiovascular diseases (6).

In summary, aerobic exercise stands out as the most recognized and efficacious strategy for both preventing and addressing cardiovascular dysfunction associated with aging. Research has consistently demonstrated that aerobic activity positively influences arterial function by effectively altering the underlying mechanisms related to aging. However, despite these benefits, engagement in aerobic exercise among older adults remains insufficient. Consequently, the obstacles to participation in aerobic exercise for this group need further investigation (7).

Resistance training and cardiovascular health

While aerobic exercise is traditionally associated with cardiovascular health, resistance training also plays a significant role. Resistance training involves exercises such as weight lifting, resistance band exercises, and bodyweight exercises, which are designed to improve muscular strength and endurance. Recent research suggests that resistance training can positively impact cardiovascular health by reducing

resting blood pressure, improving arterial stiffness, and enhancing endothelial function (8, 9). Cornelissen and Smart (2013) conducted a meta-analysis that demonstrated the efficacy of resistance training in lowering blood pressure, especially when combined with aerobic exercise (10). The study highlighted that resistance training could be particularly beneficial for elderly individuals with hypertension, offering a complementary approach to traditional aerobic exercise.

One of the key cardiovascular benefits of resistance training is its ability to reduce resting blood pressure, which is a critical factor in preventing cardiovascular diseases. High blood pressure is a major risk factor for heart disease, stroke, and other cardiovascular conditions, especially in older adults (11). In addition to lowering blood pressure, resistance training has been shown to improve arterial stiffness, another important determinant of cardiovascular health. Arterial stiffness refers to the loss of elasticity in the arteries, which increases the workload on the heart and is associated with a higher risk of cardiovascular events. A study by Miyachi et al., investigated the effects of resistance training on arterial stiffness in older adults and found that regular resistance exercise led to a significant reduction in arterial stiffness (12). This improvement is crucial for maintaining healthy blood pressure levels and reducing the risk of heart disease (13).

Resistance training also positively influences endothelial function, which is essential for maintaining vascular health. The endothelium, the inner lining of blood vessels, plays a critical role in regulating blood flow and preventing the formation of blood clots. A study by Rakobowchuk et al., demonstrated that resistance training improved endothelial function in older adults, particularly by enhancing the endothelium's ability to produce nitric oxide, a molecule that promotes vasodilation and blood flow (14). Improved endothelial function contributes to overall cardiovascular health and helps prevent atherosclerosis, a condition characterized by the hardening and narrowing of the arteries (15).

Furthermore, resistance training has been associated with favorable changes in body composition, such as increased muscle mass and reduced visceral fat, which are important for cardiovascular health. Visceral fat, which surrounds internal organs, is strongly linked to cardiovascular disease and metabolic disorders. A study by Davidson et al., found that resistance training significantly reduced visceral fat in older adults, thereby lowering their risk of cardiovascular diseases. The reduction in visceral fat, combined with increased muscle mass, enhances metabolic health and reduces the strain on the cardiovascular system (16).

Overall, resistance training offers a range of cardiovascular benefits for the elderly, including lowering blood pressure, reducing arterial stiffness, improving endothelial function, and promoting favorable changes in body composition. While aerobic exercise remains a cornerstone of cardiovascular

health, incorporating resistance training into the exercise routines of older adults provides a comprehensive approach to preventing and managing cardiovascular diseases. This dual approach not only enhances heart health but also supports overall physical function and quality of life in the elderly (17).

Moreover, resistance training helps improve vascular health by reducing arterial stiffness, a key risk factor for cardiovascular diseases in older adults. A study by Okamoto et al., found that older adults who engaged in regular resistance training exhibited significant improvements in arterial compliance, which is essential for maintaining healthy blood pressure and reducing the risk of cardiovascular events (18). This study underscores the importance of incorporating resistance training into the exercise routines of elderly individuals to achieve comprehensive cardiovascular health benefits.

Musculoskeletal health: combatting sarcopenia and osteoporosis

Aging is associated with a decline in muscle mass, strength, and bone density, leading to conditions such as sarcopenia and osteoporosis, which increase the risk of falls and fractures. Resistance training is the most effective exercise modality for combating these age-related musculoskeletal changes. According to a review by Peterson and Gordon, older adults who engage in regular resistance training experience significant increases in muscle mass, strength, and bone density, which are crucial for maintaining physical function and independence (19). The study emphasized that resistance training should be performed at least twice a week to achieve these benefits, with exercises targeting all major muscle groups.

Sarcopenia, the age-related loss of muscle mass and strength, and osteoporosis, characterized by decreased bone density and increased fracture risk, are major contributors to disability, reduced quality of life, and increased mortality in the elderly. Both resistance and aerobic exercises play crucial roles in combating these conditions, but resistance training is particularly effective in addressing the musculoskeletal challenges associated with aging (20).

Resistance training also stimulates bone formation and increases bone mineral density, which is crucial for combating osteoporosis. Older adults who participated in high-intensity resistance training experienced significant increases in bone density, particularly in weight-bearing bones like the spine and hips, reducing the risk of osteoporosis-related fractures (23). While resistance training is highly effective for maintaining bone density, weight-bearing aerobic exercises, such as walking and running, also contribute to bone health by promoting bone maintenance and reducing bone loss. However, aerobic exercise alone may not fully prevent bone loss or combat sarcopenia. Therefore, incorporating both resistance and aerobic exercises into

exercise programs for the elderly is essential for comprehensive musculoskeletal health (25, 26).

A combined exercise program that includes both resistance and aerobic exercises has been shown to provide greater improvements in physical function and bone health than doing either exercise alone. This combination helps maintain overall musculoskeletal health and prevent the decline in physical function that often accompanies aging (27, 28).

In summary, resistance training is the cornerstone of musculoskeletal health in the elderly, offering significant benefits in preventing and reversing sarcopenia and osteoporosis. By increasing muscle mass and strength, and enhancing bone density, resistance training helps older adults maintain their independence, reduce the risk of falls and fractures, and improve their overall quality of life (21). While aerobic exercise contributes to bone maintenance and complements the benefits of resistance training, a comprehensive exercise program that includes both types of exercise is essential for optimal musculoskeletal health in older adults. Health practitioners should encourage elderly individuals to engage in regular resistance training, alongside weight-bearing aerobic activities, to combat the musculoskeletal challenges of aging effectively (22).

Cognitive function: the impact of exercise

Cognitive decline is a common concern among the elderly, with conditions such as mild cognitive impairment and dementia becoming more prevalent with age. According to the World Health Organization, approximately 50 million people worldwide are living with dementia, and this number is expected to triple by 2050. Exercise, both aerobic and resistance training, has been shown to play a crucial role in preserving and enhancing cognitive function in older adults. Numerous studies have demonstrated that regular physical activity can improve memory, executive function, and overall brain health, making it a key intervention in the fight against age-related cognitive decline (7, 8, 23).

Aerobic exercise, in particular, has been extensively studied for its positive effects on brain health. Activities such as walking, swimming, and cycling have been shown to increase blood flow to the brain, promote neurogenesis (the growth of new neurons), and enhance brain plasticity. A pivotal study by Erickson et al., found that older adults who engaged in regular aerobic exercise experienced an increase in the size of the hippocampus, a region of the brain critical for memory and learning (24). The study highlighted that the hippocampal volume, which typically decreases with age, was preserved or even increased in those who exercised regularly, leading to improvements in spatial memory and overall cognitive function.

In addition to structural changes in the brain, aerobic exercise has been linked to improved cognitive performance. These improvements have been observed in various domains, including attention, processing

speed, and executive function. A meta-analysis by Smith et al., reviewed multiple studies on the effects of aerobic exercise on cognition in older adults and found consistent evidence that aerobic exercise enhances cognitive function across different tasks (25). The study suggested that the benefits of aerobic exercise on

cognition are likely due to its effects on cardiovascular health, which in turn improve cerebral blood flow and oxygenation, supporting brain function.

Resistance training, while traditionally associated with physical benefits, also contributes significantly to cognitive health. Research has shown that resistance exercises, such as weight lifting and bodyweight exercises, can improve executive functions, including planning, decision-making, and multitasking. A study by Liu-Ambrose et al., demonstrated that older women who participated in a 12-month resistance training program showed significant improvements in executive function compared to a control group (23). The study suggested that the cognitive benefits of resistance training might be mediated by the release of growth factors, such as brain-derived neurotrophic factor, which supports neuronal health and cognitive function.

Moreover, resistance training has been found to positively impact brain structure. A study by Best et al., examined the effects of resistance training on white matter integrity in older adults and found that those who engaged in regular resistance exercises had better preservation of white matter, which is essential for efficient communication between different brain regions. The preservation of white matter is crucial for maintaining cognitive function, as its decline is associated with cognitive impairments and an increased risk of dementia (26).

The combination of aerobic and resistance exercises appears to offer the most comprehensive benefits for cognitive health. A study by Colcombe and Kramer (27) emphasized that combined exercise programs enhance various aspects of cognition, including memory, attention, and executive function, by promoting neurogenesis, enhancing brain plasticity, and improving cardiovascular health.

Furthermore, exercise has been shown to reduce the risk of developing neurodegenerative diseases such as Alzheimer's disease. A longitudinal study by Barnes et al., found that older adults who engaged in regular physical activity had a lower risk of developing Alzheimer's disease and other forms of dementia (28). The study suggested that the protective effects of exercise are likely due to a combination of factors, including improved cardiovascular health, reduced inflammation, and enhanced neuroplasticity, all of which contribute to maintaining cognitive function in aging (29).

In summary, exercise, encompassing both aerobic and resistance training, plays a critical role in preserving and enhancing cognitive function in the elderly. Aerobic exercise promotes brain health by increasing hippocampal volume, improving cerebral blood flow,

and supporting neurogenesis, while resistance training strengthens executive function and preserves brain structure (30). The combination of these exercises offers the most significant cognitive benefits, reducing the risk of cognitive decline and neurodegenerative diseases. Encouraging older adults to engage in regular physical activity is essential for maintaining cognitive health and improving overall quality of life as they age.

Metabolic health: managing diabetes and obesity

Metabolic disorders, including type 2 diabetes and obesity, are common in the elderly and can lead to a range of complications. Aerobic exercise is particularly effective in improving glucose metabolism and insulin sensitivity, which are crucial for managing type 2 diabetes (31). Sigal et al., conducted a randomized trial showing that elderly individuals with type 2 diabetes who engaged in aerobic exercise experienced significant improvements in glycemic control, reduced HbA1c levels, and decreased body fat (32). This study underscores the role of aerobic exercise as a cornerstone in the management of metabolic health, particularly in older adults at risk for or managing diabetes.

Resistance training also offers substantial benefits for metabolic health, particularly through its impact on muscle mass and insulin sensitivity (33). According to a study by Dunstan et al., elderly men who participated in high-intensity resistance training three times a week for six months exhibited significant improvements in insulin sensitivity and reductions in visceral fat, which are critical for managing diabetes and reducing the risk of cardiovascular disease (34). The study highlighted that the increase in muscle mass from resistance training enhances the body's ability to regulate blood sugar levels, making it a valuable component of diabetes management in older adults. When combined, aerobic and resistance exercises provide a comprehensive approach to improving and maintaining metabolic health in the elderly (35).

Psychological well-being: exercise and mental health

Physical activity is well-documented to have positive effects on psychological well-being, with both aerobic and resistance exercises contributing to improved mood, reduced anxiety, and enhanced quality of life (36). Aerobic exercise is particularly effective in alleviating symptoms of depression and anxiety due to the release of endorphins and the regulation of stress hormones. A study by Blumenthal et al., found that elderly individuals who engaged in regular aerobic exercise reported significant reductions in depressive symptoms and improved overall well-being compared to those who were sedentary (26). The study emphasized that aerobic exercise could serve as an effective non-pharmacological treatment for depression in older adults.

Resistance training also offers psychological benefits, although these are often less recognized (37). A study by O'Connor et al., found that older adults who participated in resistance training experienced significant improvements in self-esteem, reductions in symptoms of anxiety, and a greater sense of control over their lives. The physical improvements gained from resistance training, such as increased strength and functional capacity, contribute to a greater sense of autonomy and self-efficacy, which are crucial for maintaining mental health in the elderly (38). The study concluded that resistance training should be considered an important component of mental health interventions for older adults, especially for those who may be unable to engage in aerobic activities due to physical limitations.

Quality of life: enhancing daily function and longevity

Quality of life in the elderly is significantly influenced by physical activity, with both aerobic and resistance exercises playing crucial roles in enhancing daily function and longevity. Aerobic exercise contributes to improved endurance, energy levels, and cardiovascular health, making it easier for older adults to perform daily tasks and engage in social activities (39). Pahor et al., conducted a study that demonstrated that elderly individuals who engaged in regular aerobic exercise had a lower incidence of disability, higher levels of physical function, and a greater likelihood of maintaining independence compared to those who were sedentary. This study underscores the importance of aerobic exercise in promoting an active and fulfilling lifestyle in older adults (18).

Resistance training, while less focused on cardiovascular endurance, is critical for maintaining the strength and functional capacity necessary for daily activities. Pereira et al., conducted a landmark study showing that frail elderly individuals who participated in resistance training programs experienced significant improvements in strength, walking speed, and overall physical function (40). These improvements not only enhance quality of life but also reduce the risk of falls and related injuries, which are significant concerns in the elderly population. The study highlighted that resistance training should be a key component of exercise programs designed to improve the quality of life and longevity in older adults.

Conclusion

In conclusion, both aerobic and resistance exercises offer unique and complementary benefits for older adults, making them essential components of a well-rounded exercise program. Aerobic exercise, such as walking, swimming, and cycling, significantly improves cardiovascular health by enhancing heart function, reducing blood pressure, and increasing circulation. It also plays a key role in preserving

cognitive function, improving attention, memory, and processing speed, and reducing the risk of age-related cognitive decline, such as dementia. Additionally, aerobic exercise can boost psychological well-being, reducing symptoms of depression and anxiety, which are prevalent among the elderly. On the other hand, resistance training, including activities like weightlifting, resistance band exercises, and bodyweight training, is essential for maintaining musculoskeletal health. It helps combat muscle loss and bone density reduction, reducing the risk of sarcopenia and osteoporosis. Resistance training also stimulates bone formation, promotes balance, coordination, and physical independence, and has positive effects on metabolic function. It is particularly effective in maintaining strength and preventing fractures in weight-bearing bones, such as the spine and hips.

Combining both aerobic and resistance exercises into a regular routine offers a comprehensive approach to health. This combination can improve physical function, enhance cognitive clarity, and boost emotional well-being (41). The resulting improvements in quality of life, lower risk of chronic diseases (such as heart disease, diabetes, and hypertension), and reduced risk of falls are invaluable in maintaining the independence of elderly individuals (42).

Health practitioners and caregivers should encourage older adults to engage in both aerobic and resistance exercises regularly to maximize health benefits. However, it is important to recognize that the exercise needs of older adults vary based on their age, health status, and mobility. Personalized exercise plans should be created, ensuring the intensity, duration, and type of exercise are tailored to each individual's specific needs (43). While the benefits of aerobic and resistance exercises are clear, it is important to consider the potential risks and limitations, particularly for elderly individuals with pre-existing health conditions (44). These may include an increased risk of injury from falls, muscle strains, or joint pain. Additionally, older adults with cardiovascular problems, osteoporosis, or arthritis may need to modify the intensity or type of exercise to reduce strain on their bodies. For instance, high-impact aerobic exercises may be too strenuous for those with joint problems, and heavy weightlifting may not be appropriate for individuals with osteoporosis (45).

A thorough medical assessment should be conducted before beginning any exercise program to ensure safety and prevent potential risks. Furthermore, it is essential for elderly individuals to start with low to moderate-intensity exercises and gradually increase the intensity as their strength and endurance improve. Monitoring progress and adjusting exercise plans as needed is crucial to minimize the risk of injury or overexertion (46).

Despite the clear benefits, further research is needed to determine the optimal combination, intensity, and duration of aerobic and resistance exercises for elderly

individuals with different health conditions. Research should focus on developing exercise guidelines tailored to specific age-related issues such as cognitive decline, joint health, and balance. Long-term studies are essential to assess the sustained benefits of exercise and refine evidence-based recommendations for promoting healthy aging.

Conflict of interest

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