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Age-Related Cognitive Impairment in Apparently Healthy Older Adults

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Age-Related Cognitive Impairment in Apparently Healthy Older Adults

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Abstract: Significant increases in age-related cognitive impairment (ARCI) associated with aging have been observed among older adults, negatively affecting measures of Quality of Life (QOL). **Purpose**: To examine the effects of a 12-week aerobic and cognitive training intervention on cognitive function in apparently healthy older adults. **Methods**: Six participants (40-75 years) were randomly placed into one of three training groups: 1) aerobic, cognitive, and flexibility (AER/COG); 2) aerobic and flexibility (AER); or 3) cognitive and flexibility (COG). There was a complete physical and cognitive assessment administered before and after the 12-week intervention. Individuals were assigned to 36 one hour sessions in total, participating three times per week. **Results**: There were no significant effects observed between all groups and variables. There were no significant increases in any measure for the COG group. There were significant ($p < 0.05$) increases in reaction time for the COG/AER group. There were significant ($p < 0.05$) increases in VO2peak and a trend toward significant ($p < 0.07$) improvements in delayed recall (DR) for the AER group. **Conclusion**: Results are preliminary, but suggest that chronic aerobic exercise for at least 30 minutes a day, three times a week can positively affect cognitive and physiological function.

Keywords: *quality of life, aerobic training, cognitive training, cancer rehabilitation*

The population in the United States is steadily rising. Older adults, specifically those considered "baby boomers," are reported to be among groups with increasing population numbers. With aging there are many different medically-related issues that may potentially arise. Within the lay and academic literature, cognitive function throughout the aging process has gained in popularity. As of the 2010 census, approximately 35 million people over the age of 65 have been reported to reside in the United States (Werner, 2011). Of these 35 million people, it is reported that an estimated 5 million people may have some form of cognitive dysfunction (Center for Disease Control and Prevention, 2010). Mild Cognitive Impairment (MCI) has been a term broadly used among this population to address some of the age-related cognitive declination such as Alzheimer's disease or dementia (Vega & Newhouse, 2014). However, more recently the term Age-Related Cognitive Impairment (ARCI) was introduced (Brennecke et al., 2014). ARCI may be a troubling phenomenon for older adults with cognitive difficulties considering the lack of treatment options available for conditions such as Alzheimer's, dementia, and MCI. In addition, the body of literature is lacking in regards to knowledge on ARCI; therefore, it is of great importance to develop interventions centered around reducing, delaying, or even potentially reversing the effects of ARCI, thereby positively affecting measures of quality of life (QOL) (Vega & Newhouse, 2014; Zelinski, Dalton, & Hindin, 2011).

Mild Cognitive Impairment

MCI has been reported to be a stage of mental impairment somewhere between normal cognitive function and dementia (Vega & Newhouse, 2014). It is estimated that 10-20% of adults over the age of 65 suffer from MCI (Alzheimer's Disease Health Center, 2012). MCI has also been reported to be associated with future development of dementia or Alzheimer's, which alarmingly, suggests a need to develop effective methods of addressing it (Shan, 2013). MCI is often observed in adults over the age of 65, with issues of cognitive decline such as episodic memory function, executive control, as well as visuospatial abilities (Vega & Newhouse, 2014). Research has shown that there are several different characteristics of MCI including self-reported cognitive complaint, objective cognitive impairment, which are classified by the severity of symptoms presented (Vega & Newhouse, 2014). MCI has been reported to be better addressed today, when treated early, than was in previous years. Studies treating the long-term effects of MCI have not consistently produced positive results; although, interventions performed during the earlier stages of MCI, even pre-MCI interventions, have indicated positive improvements that are compensatory, such as an increased ability to process, an increase in memory, and an increase in cognitive functioning among an elderly population (Vega & Newhouse, 2014).

Dementia

Dementia is a term for diseases and conditions characterized by a decline in memory or other thinking skills that affects a person's ability to perform everyday activities (Alzheimer's Association, 2014). Symptoms often include memory loss, severe mood changes, and difficulties communicating (O'Reilly, 2011). The Alzheimer's Association reported that one in nine people ages 65 and older suffers from some degree of dementia. This tends to create a difficult environment for the individuals suffering from dementia because of the impedance of activities of daily living. When there is a loss of ability to perform normal everyday activities, there may be detrimental negative consequences on QOL (Bass et al., 2014). It is important that treatments to reduce or reverse the effects of dementia are made more readily available (Bass et al., 2014). Research is rather limited with regards to interventions or treatment modalities resulting in positive effects of combating dementia but there has been support that interventions administered at life-at-home and community care organizations have the potential to increase psychological outlooks towards social support systems, which is a small progression towards increasing overall QOL (Bass et al., 2014).

Alzheimer's Disease

Alzheimer's disease (AD) is another issue of concern among older adults. As of the year 2000, there were an estimated 411,000 new cases of AD. For 2010, that number was estimated to be 454,000, which suggests an increase of approximately 10%. By 2030, it is projected to be 615,000, which is a 50% increase from 2000 (Alzheimer's Association, 2014). It is difficult to diagnose the disease because the symptoms are the same with ARCI, dementia, and even some normal aging patterns (Shan, 2013). AD has also been reported to be incurable and is, ultimately, considered to be a terminal disease in advanced stages (Gandy, 2005; Shan, 2013). The most common type has been referred to as late onset AD, which characteristically appears in adults of at least 65 years. Late onset AD makes up roughly 90% of all cases of AD (Alzheimer's Disease Health Center, 2012). There are few treatments available, and most of them simply delay the process of brain volumetric reduction. Shan (2013) reported that dysfunctional levels of enzymes such as acetylcholinesterase may be linked to short-term memory and learning (Shan, 2013). In patients with AD, excess amounts of acetylcholinesterase have been reported to negatively affect cognitive function by breaking down acetylcholine, thereby decreasing availability of the neurotransmitter (Shan, 2013). Without healthy levels of acetylcholine, neuronal function may be inhibited. By providing interventions aimed at restoring normal neurological functioning, it may be possible to attenuate the deterioration of the brain and cognitive function.

Quality of Life

QOL is a very subjective, self-reported measure that essentially assesses contentment and satisfaction with life. This is one of the most important factors to consider when evaluating those from an aging population. As the literature has suggested, it is very common for "normal" physical and cognitive functioning to become more complicated (Ball, Edwards, Ross, & McGwin, 2010). When this occurs, it is very common for these adults to lose autonomy, which may negatively affect QOL. Research has suggested that cognitive training or aerobic exercise have been associated with improvements in QOL (Agarwal, 2012; Ball et al., 2010; Fillit et al., 2002). Quality of life is a crucial aspect in the rehabilitation process of ARCI patients. Ideally, improvement in measures of cognitive functioning while also increasing QOL would optimize the rehabilitative process

Exercise

Research has indicated that multiple forms of aerobic and anaerobic exercise have been linked to improvements in QOL (Johnson, 1985; Lees & Hopkins, 2013). In addition, multiple studies have corroborated the benefits of exercise on different measures of cognitive function among older adults (Fillit et al., 2002; Zhao, Tranovich, & Wright, 2014). Recently, our lab evaluated the effects of aerobic and cognitive training on cognitive function in cancer survivors concluding the importance of aerobic training on assisting with improvements of cognitive function after treatment (Medrano et al., 2014). ARCI may present negative adaptations in brain structure, however, there is support that exercise may alter brain composition by increasing the amount of gray and white matter in the subgyral, cuneus, and precuneus region which are associated with aspects of cognitive function (Tseng et al., 2013).

Endurance training and resistance training have shown to increase many different physiological functions as well as positively affect mood states (Legrand, 2014; Vina, Sanchis-Gomar, Martinez-Bello, & Gomez-Cabrera, 2012). Investigators have reported increases in self-esteem, improved mood, created positive states of mind, and increased self-perceptions of physical condition immediately following exercise interventions (Legrand, 2014). Chronic exercise may also prolong many of the positive benefits while decreasing some of the negative effects of aging (Vina et al., 2012).

Finally, while looking at the benefits of exercise on brain tissue, multiple studies have reported structural and functional increases with aerobic exercise. Many adaptations such as neurogenesis, angiogenesis, an increases in hippocampal volumes, connectivity, and plasticity of neural tissue have been reported to occur when examining the effects of an aerobic exercise intervention consisting of 60 minutes, occurring six times per week (Lees & Hopkins, 2013). This suggests that exercise may support neuronal growth and increase vasculature leading to increases in nutrient supply and connectivity. An increase in plasticity was reported to be related to multitasking activities, sensation, cognition, memory, motor control all contributing to combating age-related tissue loss following the completion of (Tseng et al., 2013; Mahncke, Bronstone, & Merzenich 2006). Plasticity refers to an organisms (such as a neuron or glial cell) ability to alter its own structure and function as a response to an environmental stressor (Skipper, Weiss, & Gray, 2010). The benefits of this previous research can't be ignored when looking to further treat any types of cognitive impairment. Brain volume reduces with age, resulting in memory loss, decreases in motor control, and executive function, which has been reported to be a composite of multiple cognitive processes including: attention, concentration, instinct, or intuition (Diamond, 2013). Exercise can potentially prompt growth of tissues, neurons, vasculature as well as a create stimulus, therefore, it is important to examine the relationship between exercise and age-related cognitive impairment.

Cognitive Training

Research has indicated the importance of cognitive training on various measures of cognitive function among older adults (Ball et al., 2010; Fairchild, Friedman, Rosen, & Yesavage, 2013). In addition, multiple studies using computer-based cognitive training programming have resulted in increases in multiple aspects of cognitive function such as memory, attention, executive function and speed (Gates, Sachdev, Fiatarone Singh, & Valenzuela, 2011; Rebok et al., 2014; Wilhelm & Brigitte, 2005). Cognitive training targeting aspects of memory using multiple written tests, provide support that it can be a feasible intervention for ARCI (Pathak & Montgomery, 2014; Vega & Newhouse, 2014; Wilhelm & Brigitte, 2005). Benefits of cognitive training may transcend all age groups, yet it would appear that older adults may have a greater need for cognitive training because of the rapid deterioration of abilities stemming from ARCI.

Cognitive training whether administered with an interactive software or a series of written trials, may also be compensatory or neuroprotective, when used as an intervention to combat ARCI (Petersen et al., 2014). In a systematic review examining the effects of cognitive training in the form of memory tasks on an older population, the results indicated moderate improvements on memory tasks and cognitive function when examining cognitive training of intervals between 6-52 week interventions from one to five times per week (Gates et al., 2011).

Cognitive training may also enhance executive function, which is the administration of cognitive control over everyday tasks like memory, thinking, and problem solving (Padilla, Perez, Andres, & Parmentier, 2013). The benefits of cognitive training seems to target multiple components of overall cognitive function, resulting in an overall improvement of reaction time, an important component of cognitive function. An improvement in cognitive function lends support to the hypothesis that QOL may also improve because of the increased ability to successfully perform activities of daily living (ADL's).

For this research project, the effects of cognitive and aerobic training on the aging adult population was evaluated. Roughly 14 percent of people have been reported to exhibit signs of MCI or ARCI after the age of 65 (Alzheimers Association, 2014) Cognitive training methods including executive function tasks, have been reported to increase in measures of cognitive function to a greater extent than apparently healthy adults (Zelinski et al., 2011). With normal aging, often times there can be a loss in cognitive ability, which has been reported to be associated with decreases in QOL (Fillit et al., 2002). Cognitive interventions have been implemented to reduce ARCI. Individually, cognitive training and aerobic training have both been reported to increase multiple measures of cognitive function among multiple populations (Agarwal, 2012; Bass et al., 2014; Lees & Hopkins, 2013; Smith et al., 2009). Although research has indicated the effectiveness of aerobic training, cognitive training, and a combined intervention in an older cancer patient population, there have been relatively few studies that have examined the effects of a combined aerobic and cognitive training intervention on cognitive function in apparently healthy older adults.

PURPOSE

The purpose of this investigation was to evaluate the effects of a 12-week combined aerobic and cognitive training intervention on measures of cognitive function and QOL in apparently healthy older adults.

Research Question

How does cognitive and aerobic exercise affect ARCI in an apparently healthy older adult population sample?

Hypothesis

It was hypothesized that subjects participating in both aerobic and cognitive training interventions simultaneously would perform greater in measures of cognitive function, potentially positively affecting self-reported measures of QOL.

METHOD

Participants

Participants were both male and female apparently healthy adults between 40 and 75 years of age who had no history of any chemotherapy, radiation, surgery for cancer treatment, substance or alcohol abuse, psychiatric diagnoses, neurological disease, cardiovascular issues or any visual or auditory impairment. The participant's referral came from the University of Northern Colorado campus as well as surrounding areas in the community of Greeley, CO. Participants were disqualified from this study if they had undergone any software based cognitive training such as Luminosity® or My Brain Trainer®, 6 months prior to the study, or if they underwent aerobic activity such as walking or jogging frequently, meaning more than twice a week, for 8 weeks prior to starting the study. Upon meeting inclusion criteria and signing the informed consent sheet used as part of the International Review Board policy, participants were randomly assigned to one of the three experimental groups: aerobic, cognitive, and the combination of aerobic and cognitive training. It was assumed that all of the participants would abide by all of the parameters of the study. It was assumed that the participants were giving their best efforts in training, regardless of their intervention group.

Design

This study was a quasi-randomized, controlled intervention. Three separate independent variables that were measured were the aerobic training only, cognitive training only, and the combination of aerobic and cognitive training. Participants completed a pre and post physical assessment to determine cardiorespiratory endurance. Rocky Mountain Cancer Rehabilitation Institute protocol was used for this assessment and results were recorded to measure pre-to-post discrepancies. Cognitive tests were also administered before and after a 12-week intervention. QOL was also measured with all participants before and after the 12-week intervention to look at any differences associated with the three training groups. This study completely followed and adhered to the guidelines established by the approval from the University Institutional Review Board.

Training was conducted on the Motion Fitness Brain-Bike® with a built in computer installed with Neuro-Active® software composed of cognitive training exercises. Tables 2 and 3 display the types of activities that were performed every session. The participants completed 36 training sessions which were approximately an hour in duration. The primary trainer supervised each training session for all groups as outlined in table 2. Physiological results were recorded by students of the University of Northern Colorado Exercise Science program as well as the Exercise Physiology graduate students under the supervision of doctoral students and professors. The cognitive results were collected and analyzed by volunteer graduate level psychology students. Training was conducted in one of two specific “Brain Bike” rooms at the Rocky Mountain Cancer Rehabilitation Institute (RMCRI) on the University of Northern Colorado campus. The RMCRI is a well-known and nationally recognized rehabilitation facility that continuously maintains referral based clients of cancer patients with treatment-related side effects, and possesses a facility and resources making this study possible.

Preliminary Paperwork

Participants completed a medical history evaluation as well as a lifestyle evaluation. Participants also completed a Beck Depression Inventory, Piper Fatigue Questionnaire, and a Quality of Life Index prior to and following the intervention. Participants met inclusion criteria based on the medical history and lifestyle evaluations. The Beck Depression Inventory, Piper Fatigue Questionnaire, and the Quality of Life Index are used to measure psychological factors.

Physiological assessments consisted of resting heart rate, resting blood pressure, O_2 saturation, skin folds, and circumference measures for assessment of body fat percentage. These assessments were conducted at the beginning and then again post intervention. During each session throughout the 12-weeks, exercise heart rate and O_2 saturation were recorded.

The Beck Depression Inventory was used to measure depression (Salkind, 1969). It contains 21 questions and scores range from 0 to 63, in which a score above 40 indicates severe depression. Zero, on the other hand, indicates no signs or symptoms of depression (Salkind, 1969).

The Piper Fatigue Questionnaire was used to assess fatigue (Piper, Dibble, Dodd, Weiss, Slaughter, & Paul., 1998). This measure assessed total fatigue with affective, behavioral, cognitive, mood and sensory subscales. These subscales are compiled of 22 points, which when combined and averaged, gives an average of total fatigue. A zero on this scale of zero to ten would reflect no signs of fatigue, while a seven or higher would reflect severe fatigue (Piper et al., 1998).

Measurement of QOL was assessed via the Ferrans and Powers Quality of Life Index (Ferrans

& Powers, 1985). This included 66 questions evaluating health, social satisfaction, as well as family and psychological factors. Categories were added up to give the overall Quality of Life score. The higher the scores indicate higher QOL, as well as overall satisfaction of life (Ferrans & Powers, 1985).

In conjunction with the Psychology department, an hour long cognitive battery was administered prior to and following the 12-week intervention. Specific measures of cognitive function were tested including: the Wechsler Memory Scale, General Cognitive Screener, Trail-Making A, Wechsler Adult Intelligence Scale, Letter/Number Sequencing, Coding, Trail Making B, Wechsler Memory Scale, Logical Memory I & II, Controlled Oral Word Association Test (COWAT), Wechsler Adult Intelligence Scale, and the Block Design, respectively. Table 1 below provides an overview of these measures, which were obtained pre and post intervention.

Table 1. Cognitive testing battery

Neuropsychological Construct	**Instrument**
General cognitive functioning	Wechsler Memory Scale, 4th ed. (WMS-IV) - General Cognitive Screener
Processing speed	Trail-Making A
Working memory, executive function, attention	Wechsler Adult Intelligence Scale, 4th ed. (WAIS-IV) – Letter Number Sequencing, Coding
	Trail Making B
Verbal learning & memory	Wechsler Memory Scale, 4th ed. (WMS-IV) – Logical Memory I and II
Verbal fluidity	Controlled Oral Word Association Test (COWAT)
Perceptual reasoning	Wechsler Adult Intelligence Scale, 4th ed. (WAIS-IV) – Block Design

Training Intervention

Aerobic Training Only

The participants attended 36 sessions over the course of the intervention. The participants involved warmed up for five minutes on the cycle ergometer at their own preferred pace. Thirty minutes of aerobic training was then completed e session, for 36 sessions, totaling 18 hours of total training. Following training, every participant stretched statically for 30 minutes targeting major muscle groups throughout the body including, neck, shoulders/chest, posterior upper arm, upper back, lower back, hips, torso, anterior thigh and hip flexor, posterior thigh, groin, and calf (Baechle & Earle, 2008). Cardiovascular training was divided into 4-week segments, targeting 55% of heart rate reserve (the difference between max heart rate and resting heart rate) for the first four weeks, and increasing to 60% for the second four weeks, and lastly increasing to 65% for the final four weeks. Pulse oximeters were used to monitor heart rate as well as saturation of oxygen during exercise.

Cognitive Training Only

This intervention group also completed the cognitive intervention while on the cycle ergometer using the computer interface attached. These participants did not use the cycle ergometer for exercise purposes. The intervention modules were composed of 30 minutes, followed by 30 minutes of the exact same stretching routine all other subjects participated in. The progression of activities has been previously established by manufacturer to allow for optimal advancement of cognitive functions. There were seven steps administered in specific order determined by the manufacturer. The schedule is shown in table 2. The cognitive exercise identified in the “Training Exercises” column are listed and described in the table 3.

Aerobic and Cognitive Training

This intervention group trained both cognitively and aerobically at the exact same time using the cycle ergometer as well as the computer interface attached to the cycle ergometer. This was done using the exact same protocol for the aerobic training and the cognitive training. The same parameters for using HRR were used throughout the 12 weeks to keep the groups controlled. The same order of exercises for cognitive training were used also to ensure the groups were controlled accurately. Flexibility was also completed for 30 minutes following the combined intervention. This procedure is directly outlined in table 2 below.

Table 2. Aerobic training schedule and cognitive training exercises

Week	% HRR	Session	Training Exercises
1	.55	1-3	1-5, 1-5, 1-5
2	.55	4-6	1-5, 1-5, 6 (step 10)
3	.55	7-9	6 (step 9-7)
4	.55	10-12	6 (step 6-4)
5	.60	13-15	6 (step 3-1)
6	.60	16-18	1-5, 1-5, 1-5
7	.60	19-21	1-5, 1-5, 7 (step 10)
8	.60	22-24	7 (step 9-7)
9	.65	25-27	7 (step 6-4)
10	.65	28-30	7 (step 3-1)
11	.65	31-33	1-5, 1-5, 1-5
12	.65	34-36	1-5, 1-5, 1-5

Table 3. Cognitive exercises

Number	Exercise	Trained Functions	Description
1	Parking	Working Memory Visio-Spatial Memory	Adaptation and classic visuo-spatial span task
2	Car Driving	Processing Speed Divided Attention Selective Attention Vigilance	Two simultaneous biconditional discrimination (S-R) tasks with a vigilance task
3	Smart Driving	Processing Speed Selective Attention Attentional Flexibility Useful Field of View Divided Attention Vigilance	Derived from ACTIVE trial; with UFOV program
4	The Policeman	Working Memory Verbal Processing Speed	Standard n-back task with adaptable time limit
5	Brain Twister	Processing Speed Cognitive Control Attentional Flexibility	STROOP-like based on cue and response conflict and attentional set-shift paradigm
6	The Pilot	Divided Attention	Dual monitoring task

		Temporal Perception Arithmetic	
7	Stock Exchange	Processing Speed Divided Attention Working Memory	Two simultaneous n-back tasks: one audio-verbal and the other visuo-spatial

Data Collection and Safety

Data collection and handling procedures were in full compliance with Health Insurance Portability and Accountability Act (HIPAA) rules and regulations regarding the protection and privacy of each human participant as required. The data from the individual session were recorded in training booklets which were locked in a filing cabinet located inside the RMCRI in a locked office and only accessible to trainers working with individual participants. All the paperwork and information regarding this study will be kept for three years beyond completion of this study.

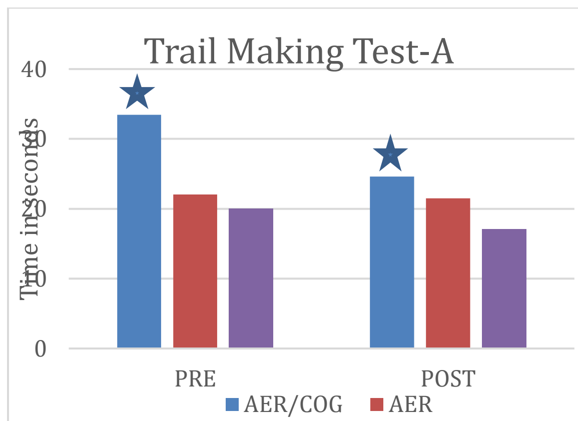
Statistical Analysis

All participants' results were recorded on the pre- and post- assessments. The post- minus pre-differences were recorded for the battery of physical, cognitive, and psychological test variables. A Kruskal-Wallis nonparametric analysis was performed on pre-to-post group differences between the three interventions (Conover, 1999; Graphpad, Inc., La Jolla, CA). Lastly, using Statistical Package for the Social Sciences (SPSS, 21), analysis of pre to post group differences were analyzed using dependent measures t-tests. The significance was set at P < 0.05.

RESULTS

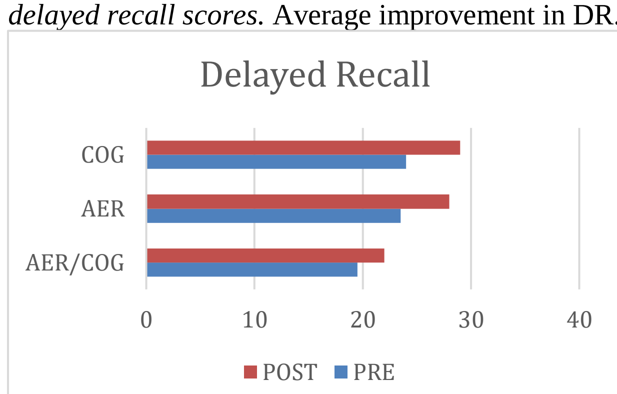
It was hypothesized that a combination of aerobic and cognitive training intervention would lead to greater performances in aspects of cognitive function, which would potentially increase self-reported QOL. However, analysis of the three training interventions revealed no significant ($p > 0.05$) main effects found between all three groups and variables. Within groups dependent measures t-tests revealed significant ($p < 0.05$) increases in reaction time for the trail making test-A (TMT-A) were observed for the AER/COG group. Dependent measures t-tests revealed no significant ($p > 0.05$) increases in any measure tested for the COG group. There were significant ($p < 0.05$) increases in VO_{2peak} (Figure 3) and a trend toward significant ($p = 0.07$) improvements in delayed recall (DR) for the AER group (Figure 2). There were no significant pre-to-post differences in QOL observed within each group.

Figure 1. Trail making test-A.



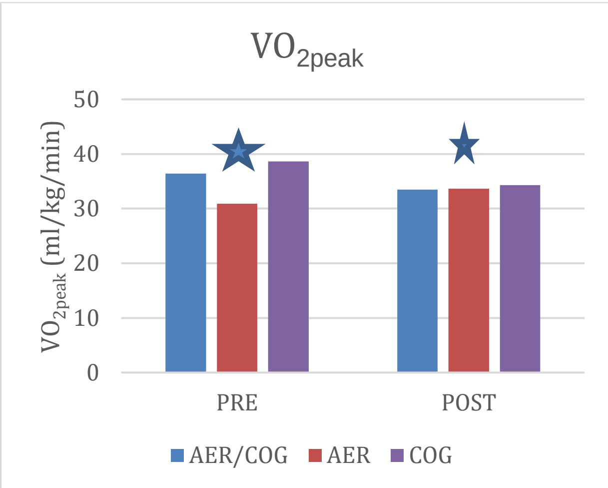
Note: ★ = significant differences from pre-post ($p < 0.05$)

Figure 2. Weschler Memory Scale Logical Memory II delayed recall scores. Average improvement in DR.



Note: AER group trended in significant increases ($p = 0.07$).

Figure 3. VO_{2peak}.



Note: ★ = significant differences from pre-post ($p < 0.05$)

DISCUSSION

Apparently healthy older adults may experience negative cognitive and physical side effects with aging, which may be attributed, in part, to ARCI. The Kruskal–Wallis test established very few significant differences in this study. It is important to note that the sample size for this project was 6 total participants. This small sample size is largely responsible for any potential skewed data as well as the lack of significant results. When one subject improved greatly, and the other subject made a small improvement, the average was not a great representation for the overall group. This was evident on several occasions throughout this process. There is still support throughout the literature that it is beneficial to create an intervention plan that focuses on the improvement of aspects of cognitive function as well as physical aspects, so the lack of significance in these specific results does not seem to be enough to discard the idea of a combined training intervention.

The AER group yielded significant improvement in reaction time and VO_{2peak} as well as a trend in significance for improvements in DR in the 12-week aerobic intervention. Other research looking at the importance of physical activity has supported that exercise and daily physical activity is an efficient way to combat and reduce risk of cardiovascular disease (CVD) regardless of age (Agarwal, 2012). Even though this research is looking primarily at CVD, it does talk about how exercise is one of the key factors when looking at improving QOL (Agarwal, 2012). Although significant improvements in QOL were not observed for any of the three groups in this study, research still supports that regular exercise may directly correlate with an improvement in QOL.

With the COG group, there were no significant increases observed for any measure of interest. This doesn't align with multiple studies that show support for cognitive training alone being effective in improving aspects of cognitive function (Gates et al., 2011; Petersen et al., 2014). It was reported that a an intervention of cognitive training with an elderly population lead to a decrease of self-reported issues with ADL's (Rebok et al., 2014). It has also been seen in cognitive training with patients suffering from AD, that there is promise for treating ARCI and aspects of cognitive function that are involved (Sitzer, Twamley, & Jeste, 2006). Research investigating how cognitive training can improve longevity of mental processing, which in turn can improve QOL, has concluded with beneficial results, but this overall 12 week treatment plan might not have been the most adequate plan for seeing improvement (Sitzer et al., 2006). The fact that no significant results came from this treatment group also could support the idea that this training protocol might not be as effective as hypothesized.

The combined AER/COG group also produced several interesting results. The only significant improvement observed was reaction time. While the individual AER and COG groups did not significantly increase in this measure, the COG/AER group did. This may be explained by increase in executive function from the combined training. This might be reason to support the idea that there is potential to improve aspects of cognitive functioning with this combined treatment. It would most likely need to be investigated with a much larger sample size to truly tell whether it can be more effective. The results for the AER/COG group showed a slight decrease in VO_{2peak}. This is interesting because it was the exact same aerobic intervention that the AER group used, which was the only group who didn't show detrimental change. This could be due to the difficulty of the cognitive training program. This program was very difficult to do by itself, (which may explain the lack of significant improvements for the COG group) but it might have been much too hard to complete the aerobic exercise while simultaneously performing cognitive exercises.

Conclusion

The results of this study suggest that aerobic training may increase cardiovascular function and aspects of cognitive function. These results also imply that cognitive training may play a role in positively affecting reaction time. Finally, these results demonstrate the importance of including at least 30 minutes of aerobic activity at a moderate intensity to potentially reduce some symptoms of ARCI. Even though this project failed to yield improvements of QOL, it is still regarded as an important factor to consider when working with an aging population. Further research needs to be implemented to investigate the role of aerobic and cognitive training in a larger sample, as the small sample size in this study may have contributed to the limited ability to find significance in this variable. Future research should include evaluating interaction and socializing and the direct effects of those variables on QOL. Even though it wasn't necessarily accounted for in this research, the ability to socialize and build relationships with other people, could drastically impact QOL. By understanding the mechanisms of ARCI for the purposes of decreasing some of the negative side effects, this could potentially be beneficial across multiple neurodegenerative diseases.

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