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Original Research Article

Investigating the Effect of High Intensity Interval Training and Structured Exercise on Cognitive Function Among Older Adults

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ABSTRACT

Background and Purpose: As global demographics shift toward an aging population, the World Health Organization (2024) projects that by 2050, the number of people worldwide over the age of 60 will surpass 2.1 billion, with those aged 80 years or older expected to triple to 426 million[1]. "Within this population, the prevalence of mild cognitive impairment (MCI) in adults over 60 years old ranges from 6.7% to 25.2%, with an annual rate of progression from MCI to dementia estimated between 5% to 17%"[2]. This demographic transition presents unprecedented challenges in maintaining cognitive health among older adults. Methods**:** This study examined the cognitive effects of high-intensity interval training compared to a prescribed fitness plan among UWEC's Community Fitness Program (CFP) members aged 45-80. Participants of the intervention group (high intensity interval training) and the control group were asked to commit to 2-3 workouts a week for four weeks. To evaluate cognitive function, participants completed a Stroop test, which evaluates an individual's speed and accuracy during cognitive interference. Three Stroop tests were conducted throughout the semester: baseline, post-intervention, and two weeks post-exercise to evaluate the effects of detraining. **Results:** The two-way repeated measures ANOVA ($p<.05$) indicated voice portion of Stroop assessment (pretest, posttest, and follow-up) and Group (control, intervention) were not significant predictors of improving reaction time, $F(2,34) = 4.280$, $p = .022$. and $F(1,17) = 1.228$, $p = .283$, respectively. In addition, no significant interaction effect was examined, $F(2,34,30) = 2.352$, $p = .110$. The two-way repeated measures ANOVA ($p<.05$) indicated the keyboard portion of Stroop assessment (pretest, posttest, and follow-up) and Group (control, intervention) were not significant predictors of improved reaction time $F(1.424,24.214) = 5.72$, $p = .016$ and $F(1,17) = 0.01$, $p = .936$, respectively. In addition, no significant interaction effect was examined, $F(1.424,24.214) = 1.176$, $p = .310$. **Conclusions:** Regular exercise intervention, no matter the type, has proven to be effective at preventing both physical and cognitive impairments in middle to older aged adults. This leads to greater choice autonomy as individuals can choose exercise modalities based on personal preferences. This in turn leads to greater adherence and overall improved cognitive and physical health markers.

Key Words: Cognitive Function, Mild Cognitive Impairment, Circuit Training, Stroop Testing

Introduction

As global demographics shift toward an aging population, the World Health Organization (2024) projects that by 2050, the number of people worldwide over the age of 60 will surpass 2.1 billion, with those aged 80 years or older expected to triple to 426 million[1]. Within this population, the prevalence of mild cognitive impairment (MCI) in adults over 60 years old ranges from 6.7% to 25.2%, with an annual rate of progression from MCI to dementia estimated between 5% to 17%[2]. This demographic transition presents unprecedented challenges in maintaining cognitive health among older adults. Age-related cognitive decline significantly alters quality of life and independence by impacting cognitive processing speed or even developing to more severe conditions like dementia. With the increasing prevalence of MCI in the aging population there is an urgent need to identify effective, accessible interventions that can preserve cognitive function in later life.

Physical activity has emerged as a promising non-pharmacological approach to mitigate cognitive decline. Research has consistently demonstrated that regular exercise promotes neuroplasticity, improves cerebral blood flow, reduces inflammation, and enhances the release of neuroprotective factors such as brain-derived neurotrophic factor (BDNF) and insulin-like growth factor 1[3]. However, the optimal type, intensity, and frequency of exercise needed to maximize cognitive benefits remain unclear, particularly for older adults who face unique physiological challenges and barriers to exercise adherence.

High-intensity interval training (HIIT) is characterized by short bursts of vigorous activity alternating with periods of rest or low-intensity exercise. It has gained much attention within the last few decades for its time efficiency and potential health benefits. HIIT has been shown to improve cardiovascular fitness, metabolic health, and physical function in older adults[4]. Recent evidence suggests that higher-intensity exercise may provide greater cognitive benefits than moderate or low-intensity activities by stimulating more neurophysiological responses[5]. However, existing literature presents inconsistent findings regarding the comparative effectiveness of HIIT versus moderate-intensity continuous training (MCT) or resistance training (RT) for enhancing various domains of cognitive function. Some studies indicate that HIIT may be particularly effective for improving information processing speed[6], while others suggest that moderate aerobic exercise or resistance training might better enhance executive function or memory[7]. These discrepancies may be attributed to variations in research methods, individual differences in baseline cognitive and physical status, or the specific cognitive domains assessed. Overall, the short-term effects of HIIT on cognitive performance, which could provide valuable insights into the acute neurophysiological responses to high-intensity exercise, have not been thoroughly investigated in older populations.

The significance of this study lies in its potential to clarify the relationship between exercise intensity and cognitive benefits in older adults, particularly the acute effects of interval training on executive function. As pharmacological interventions for MCI remain limited and often restricted to high-risk individuals due to uncertainty and potential side effects, identifying effective non-pharmacological approaches becomes increasingly important. The findings from this research may inform evidence-based exercise prescriptions that optimize cognitive health maintenance and potentially delay the onset of more severe cognitive impairment in aging populations. Despite the potential benefits of high-intensity exercise, achieving true high-intensity exertion presents significant challenges among older adult populations. Research by Donath et al. (2021) found that older adults frequently struggle to reach and maintain prescribed high-intensity zones due to age-related physiological changes, concerns about injury, and misperceptions about appropriate exertion levels[8]. Another study by Taylor et al. (2019) reported that perceived exertion ratings among older adults often underestimate actual physiological intensity, creating a gap between intended and achieved exercise intensity[9]. These findings highlight the necessity for structured interval training protocols that systematically guide older adults to appropriate high-intensity thresholds while incorporating recovery periods to make such exertion sustainable. Interval training provides a methodical framework that helps overcome the psychological barriers and physical limitations that typically prevent older adults from reaching intensity levels associated with enhanced neurophysiological responses.

The purpose of this study is to examine whether HIIT provides greater immediate benefits for cognitive function compared to structured exercise not involving high-intensity intervals in community-dwelling older adults. This hypothesis is based on the emerging evidence suggesting that higher-intensity exercise may trigger improvements in executive function and processing speed through enhanced cerebral blood flow and neurotrophic factor release.

Methods

Participants

Participants were recruited from a pool of 93 who attend the University of Wisconsin Eau Claire (UWEC) Community Fitness Program (CFP). Of the 93, three were ineligible due to color blindness, and 22 participated in the study. Seven participants were male (31.8%), while 15 were female (46.9%). Eligibility criteria included the ability to differentiate between red, green, and yellow; medical clearance for moderate- to high-intensity exercise; absence of any current neurological conditions or prescribed medications for cognitive function; and a commitment to completing the entire nineweek program (three days per week). This study was reviewed and approved by the University of Wisconsin Eau Claire Institutional Review Board (Protocol Number: 202535524). All participants provided informed consent before participating in the study.

Instrumentation

The Stroop-color word task (Testable Research Inc, 2025) online software was used to measure the cognitive parameters of executive functions such as working memory and inhibitory control. Testable Research Inc out of Delaware, was founded by a group of behavioral scientists and researchers. The software company specializes in allowing users to create a variety of assessments and surveys, specifically for psychological experimentation. The assessment measures the ability to inhibit cognitive interference, which occurs when the processing of one stimulus impacts the processing of a different characteristic of the same stimulus. In this case, attempting to name the color that a word is printed in on the screen and not the color that the word says. The Stroop-color word test is known for being a widely utilized neurophysiological assessment, pointing out key discrepancies in executive function (through reaction time and accuracy of testing) especially in the aging population[10]. Previous studies have examined the ability to inhibit cognitive interference between younger and older adults, which displayed significant differences between groups with older adults reporting much poorer reaction time[11]. Additionally, a study by Braga et al. (2022) utilized the same cognitive assessment to measure differences in cognition between older adults of differing functional fitness capabilities. The results indicated that those who engaged in regular physical activity had greater executive function abilities compared to those of the latter[12]. The previous literature demonstrates significant variability as differences in scores between older adults highlighted potential aged-related mild cognitive impairment through testing of reaction time and cognitive inhibition as well as the impact of physical activity on these variables. Both of which were highlighted in this study. Although many variations of the test exist, the classic Stroop-color word task has proven to have quality test and retest reliability due to the consistency of participant response/reaction times[10].

Procedures

The study followed a structured procedure to examine the short-term effects of HIIT on cognitive function (see figure 1). Participants were recruited based on being over age 50 and not being diagnosed with color blindness. Participants were given the option to be a part of the control group (regular resistance training) or the HIIT group. The participants provided informed consent forms to student trainers before beginning the study. Prior to the intervention, participants completed a pre-test cognitive assessment using the STROOP test software in a controlled environment to measure baseline cognitive function.

Following the assessment, participants engaged in 2-3 HIIT sessions per week for four weeks. These sessions consisted of 2 rounds of 8 exercises (5 upper body focused and 3 lower body focused). Each exercise was performed for 40 seconds with a 20 second rest between exercise stations. After one round was completed, the participants took a 1–2-minute break before the next round. The intensity was measured by a 1-10 BORG rate of perceived exertion (RPE) scale, and the participants were asked to be in the 7-9 range. Throughout the session, check-ins and RPE were used to ensure safety and adherence to the protocol. During this time, participants of the control group did not engage in any HIIT and instead participated in their prescribed structured exercise programs with student trainers. After completing the four weeks, participants underwent a post-test cognitive assessment (STROOP) to evaluate any changes in cognitive performance (reaction speed and accuracy). Following the post test, participants were asked to refrain from HIIT for two weeks and then asked to participate in final follow up cognitive testing (STROOP) to analyze if the effects of the HIIT sessions have lasting effects over a detraining period. All data was recorded using Testable software and excel spreadsheets and later analyzed. Ethical approval was obtained from the IRB, and participants were monitored for any adverse effects, with the option to withdraw at any time.

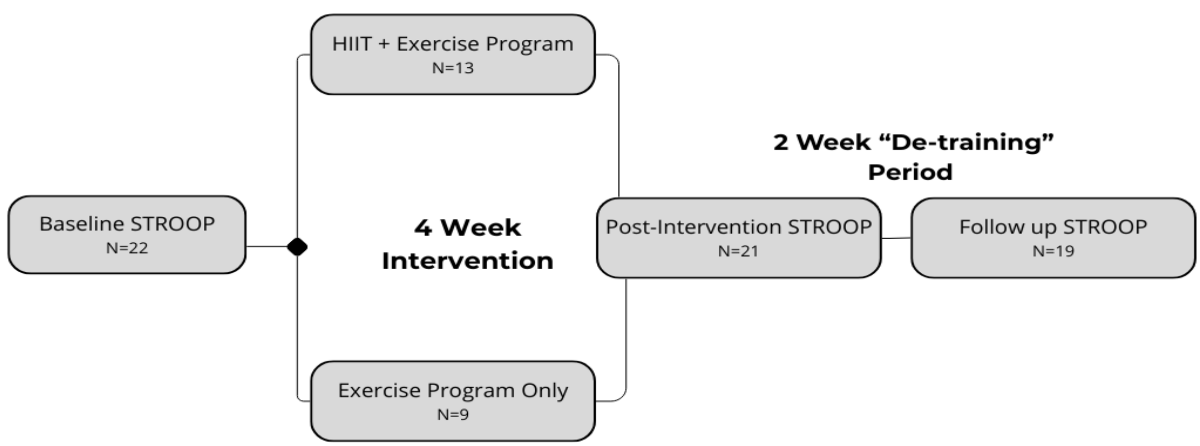


Figure 1. Recruitment Path.
Note. This figure illustrates the timeline of STROOP protocol administrations at baseline, post-intervention, and follow-up, alongside the 4-week intervention and 2-week detraining period. Participants were divided into a HIIT + Exercise Program group (*n* = 13) and an Exercise Program Only group (*n* = 9) following baseline testing (*N* = 22). Participant numbers decreased slightly at each subsequent testing point, with *N* = 21 at post-intervention and *N* = 19 at follow-up.

Design and Statistical Analysis

The design of this research is a true experimental study with pre and post testing. The study consisted of two groups, the experimental group participating in the high intensity interval training (HIIT), power and agility class, as well as their own resistance training, and the control group who were not participants in the HIIT class but still did their own resistance training. The first independent variable was the time factor. This is regarding the time of testing: pre-intervention vs post-intervention vs post-detraining. The second independent variable was whether an individual is in the control group or the experimental group. The participants were able to choose the group they wanted to participate in. The STROOP testing was randomized to avoid any of the participants remembering the previous test and artificially inflating their score. For the data analysis, the data from Testable was entered into Microsoft Excel. From there, the data spreadsheet was entered into the IBM-SPSS Software: version 29 to run a two way (group by time) repeated measures ANOVA with a significance level of 0.05.

Results

A total of 22 participants were enrolled between the structured exercise and HIIT groups following the recruitment phase. Following the 4-week intervention period and an additional two rounds of post intervention/follow-up Stroop testing, a total of 3 participants had dropped out, leaving 19 subjects' reaction time results available for statistical analysis. Primary reasons for dropout were cited as time commitment difficulties and overall lack of attendance at intervention sessions. All noted subject dropouts came from the HIIT group reflecting the potential challenge of adherence to the required exercise sessions. Study participants were analyzed on the variables of accuracy and reaction time from Stroop testing sessions, with reaction time being the only variable analyzed utilizing IBM SSPS repeated measures ANOVA (see table 1 and 2 for descriptive statistics on reaction time). Overall, accuracy of responses (number of misses) during both sections of Stroop assessment for the HIIT group increased throughout the 3 testing sessions. The proportion of participants who increased to zero misses went from 36.4%, baseline (Fig. 2a) to 45.5% post-intervention (Fig. 2b) and again 81.8% post detraining (Fig. 2c). As for HIIT group participants with 1 or more misses that improved their accuracy scores, that proportion also increased with 63.6% at baseline (Fig. 2a) to 54.6% post-intervention (Fig. 2b) and finally down to 18.2% during the follow-up test (Fig. 2c). On the other hand, the control saw differing results for proportion of subjects with zero misses, going from 62.5% at baseline (Fig. 3a) down to 37.5% in the post-intervention test (Fig. 3b). This was the same case for participants with 1 or more misses, with the proportion of participants going from 37.5% at baseline (Fig. 3a) to 62.5% at post-intervention (Fig. 3b). Both, however, did rebound during the follow-up assessment with control subjects either having zero or one miss (Fig. 3c). Using an alpha of .05, the two-way repeated measures ANOVA indicated voice portion of Stroop assessment (pretest, posttest, and follow-up) and Group (control, intervention) were not significant predictors of improving reaction time, $F(2,34) = 4.280$, $p = .022$. and $F(1,17) = 1.228$, $p = .283$, respectively. In addition, no significant interaction effect was examined, $F(2,34,30) = 2.35$, $p = .110$. Once again, using an alpha of .05, the two-way repeated measures ANOVA indicated the keyboard portion of Stroop assessment (pretest, posttest, and follow-up) and Group (control, intervention) were not significant predictors of improved reaction time $F(1.42, 24.2) = 5.72$, $p = .016$ and $F(1,17) = 0.01$, $p = .936$, respectively. In addition, no significant interaction effect was examined, $F(1.42, 24.2) = 1.17$, $p = .310$.

Table 1.
Reaction Time – Voice Response (dv1)

Training Group	Time	Mean	Std. Error	95% CI Lower	95% CI Upper
HIIT	Pre	990.962	43.365	894.338	1087.585
	Post	937.820	55.663	813.795	1061.845
	FU	932.346	50.346	820.169	1044.523
Structured Exercise	Pre	1068.621	58.434	930.448	1206.795
	Post	956.045	32.321	879.617	1032.473
	FU	1076.369	86.512	871.801	1280.936

Table 2.
Reaction Time – Keyboard Response (dv2)

Training Group	Time	Mean	Std. Error	95% CI Lower	95% CI Upper
HIIT	Pre	1109.422	64.982	972.322	1246.522
	Post	1003.843	100.183	792.476	1215.211
	FU	1002.931	60.549	875.183	1130.942
Structured Exercise	Pre	1160.177	76.198	999.413	1320.942
	Post	899.204	117.475	651.353	1147.054
	FU	1032.070	71.000	882.272	1181.867

Note. n = [insert number] per cell. FU = Follow-up testing

Figure 2a.
Baseline Number of Total Mistakes – HIIT Group

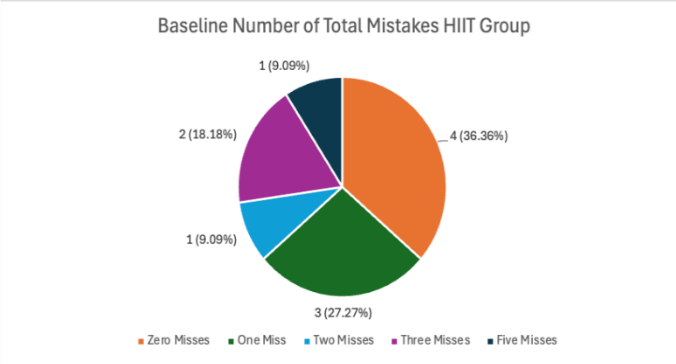


Figure 2b. Post-Intervention Number of Total Mistakes – HIIT Group

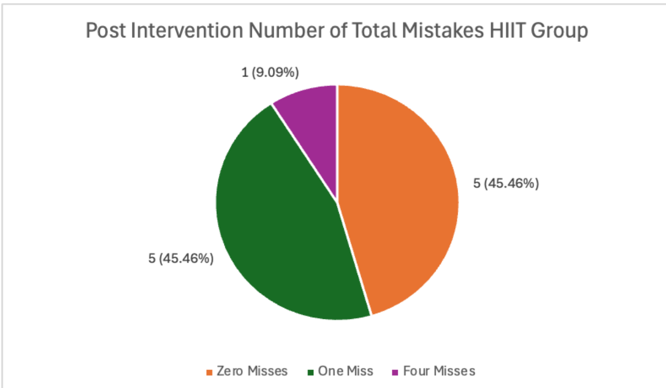
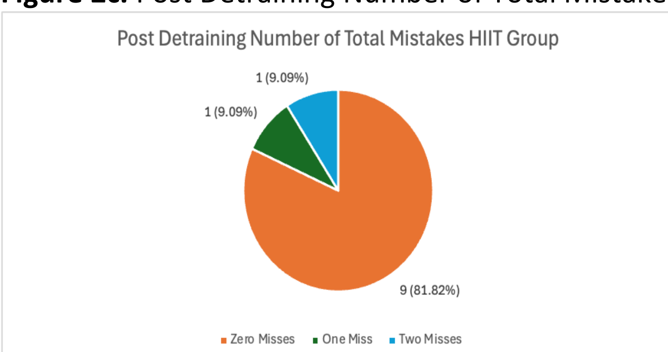


Figure 2c. Post Detraining Number of Total Mistakes – HIIT Group



Note. These figures display the number of total mistakes made by participants in the HIIT group during the STROOP test at baseline (Figure 2a.), post-intervention (Figure 2b.), and post detraining (Figure 2c.). Mistakes are categorized by frequency (e.g., zero misses, one miss, etc.). Percentages reflect the proportion of participants within each error category at each respective timepoint.

Figure 3a. Baseline Number of total Mistakes – Control Group

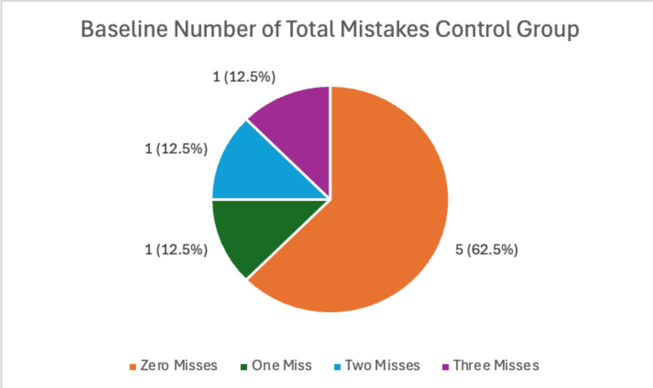


Figure 3b. Post-Intervention Number of Total Mistakes – Control Group

Figure 3c. Post Detraining Number of Total Mistakes – Control Group

Note. These figures display the number of total mistakes made by participants in the control group during the STROOP test at baseline (Figure 2a.), post-intervention (Figure 2b), and post-detraining (Figure 2c). Mistakes are categorized by frequency (e.g., zero misses, one miss, etc.). Percentages reflect the proportion of participants within each error category at each respective time point.

Discussion

The objective of this study was to examine if short-term high intensity interval training (HIIT) intervention accompanied with structured exercise programming would improve cognitive function among older adults compared to regular structured exercise not consisting of HIIT. It was hypothesized that participants engaged in regular HIIT intervention would display improved reaction time and accuracy during Stroop color-word assessment compared to the structured exercise group following 4-week intervention period and 2-week detraining period. However, results indicated no statistically significant differences existed between groups for reaction time during Stroop assessment. These findings demonstrate that short term exercise intervention of any kind may contribute to improvement in both physical and cognitive status among older adults. This leads to greater choice for older adults when deciding which exercise intervention is the best fit for them, potentially improving overall adherence.

HIIT and Older Adults

Previous literature has examined the impact of a variety of exercise modalities on cognition in the older adult population. High-intensity interval training has emerged as a particularly effective exercise modality for older adults, offering unique benefits compared to traditional continuous moderate-intensity exercise. According to Liang et al. (2024), HIIT interventions produce significant improvements in various parameters related to physical fitness and health among older adults, with measurable gains in cardiorespiratory fitness, muscular strength, and functional mobility[4]. This is especially valuable as the World Health Organization (2024) identifies maintaining functional ability as a key determinant of healthy aging[1]. Oliveria et al. (2020) conducted a systematic review and meta-analysis comparing HIIT with continuous moderate aerobic training and found that HIIT yielded comparable or greater improvements in fitness and health markers while requiring substantially less time commitment[13]. The time efficacy of HIIT emphasizes the importance of intervention fidelity and appropriate intensity prescription for optimizing outcomes. Another study by Calverley et al. (2020) highlighted that HIIT can effectively modulate cerebrovascular function and brain metabolism, suggesting mechanistic pathways through which this exercise modality might support both physical and cognitive health in aging adults[14]. HIIT is a well-tolerated exercise modality that can be individualized by older adults and is particularly important for those who have varying baseline fitness levels and health concerns.

Exercise and Cognitive Function

The relationship between exercise and cognitive function has been extensively examined in recent literature, with several studies offering valuable insights. Mekari et al. (2020) demonstrated that HIIT specifically improves cognitive flexibility in older adults, a crucial executive function that often declines with age[15]. Their findings suggest that short-term HIIT interventions can effectively enhance this aspect of cognition, contributing to independence and quality of life. The cognitive benefits of exercise can also be seen through physiological mechanisms as explained by Gao et al. (2024). Exercise-induced myokines—proteins released by contracting muscles—act as molecular messengers that can cross the blood-brain barrier and directly influence brain health. These myokines promote neurogenesis, enhance synaptic plasticity, and reduce neuroinflammation. This molecular connection between muscle and brain represents the biological pathway through which physical activity supports cognitive function[3]. This is all relevant information because Alzheimer's disease and cognitive decline are ever growing problems globally. While there is no cure for either, an article by Marston et al. (2019) discusses the different neural and vascular responses that come with resistance training. The article begins by discussing a few of the risk factors related to Alzheimer's disease. A large risk factor is atherosclerosis which can lead to cerebrovascular dysfunction. In addition, neuroplasticity is part of the equation in the development of Alzheimer's. IGF-1 is a hormone that is crucial for positive neuroplastic development. The article's research demonstrates that resistance training is a big determinant for IGF-1 release, and thus, important for the reduction in change for developing Alzheimer's. On top of that, homocysteine is an amino acid that is associated with vascular and neuronal damage, including white matter damage. Resistance training was shown to regulate homocysteine levels and can be used to prevent and postpone the development of Alzheimer's disease by affecting the many different systems that develop dysfunction by regulating them[16].

Exercise Type and Cognitive Performance

These results of this present study are in agreement with previous literature examining the effects of exercise intervention on improving cognitive performance overall, no matter the type of intervention. The "control" or structured exercise group in this study, not participating in HIIT, engaged in a variety of exercise modalities such as moderate intensity aerobic training, resistance training, etc. Moderate-intensity aerobic exercise has proven to be beneficial at improving overall cognitive performance, sleep index, and depressive like symptoms in adults 60 years of age and older comparative to inactive older adults[17]. Additionally, individuals participating in resistance training were subject to a variety of improvements as previously found by Fernandez-Gamez et al. (2023) in which participants saw improvements in functional capacity and lesser limitations in completing activities of daily living (ADL's)[18]. To further drive home the overall importance of any exercise intervention type on improving cognitive function, Northey et al. (2018), examined the impact of aerobic, resistance, Tai-Chi, and multi-variate training types in community dwelling older adults above 50 years. They found that no matter what the participants baseline cognitive function, exercise intervention of all kinds resulted in positive cognitive improvements when completed according to current physical activity guidelines[19]. Much like the pool of community dwelling older adult participants in this present study, they too are at the disposal of a wide variety of exercise modality options, all of which have proven to play some role in improvement of cognitive health and preventing MCI.

Strengths/Limitations

A strength of the study is that there was both a control group and an experimental group. Both groups saw benefits in their physical fitness, and cognitive abilities. There was little to no researcher bias within the study as the results are strictly numerical and participants were kept anonymous when analyzing results. Additionally, the method of testing cognition utilizing the Stroop color-word task is a common and accurate practice when analyzing basic cognitive function. Previous literature such as Braga et al, (2022) found this testing method to be rather significant when analyzing executive function in older adults[12]. Likewise, data was collected via electronic software, minimizing potential for user related data collection errors. The study also had a handful of limitations. One such limitation was the small sample size. This present study consisted of only 19 participants, which is significantly less than what was observed while examining prior literature in the field such as Alsubaie et al, (2020). which saw 150 participants in total. Another limitation is the lack of control of the participants outside of the Community Fitness Program. No restrictions were placed on participants outside of their individual time spent on site each week. Factors such as physical activity restrictions, maintaining a strict diet, or sleep index were not accounted/controlled for. This lack of control may have led to some overlap between control and intervention groups in terms of protocol adherence. Additionally, there was no random assignment of groups. Participants were given the option to select their own group based on personal preference. This could have contributed to variability in individual performance during Stroop assessments as it is difficult to determine whether observed differences between the groups were due to the varying kinds of exercise or because of individual fitness levels.

Conclusion

This study found no significant difference between interval training and traditional resistance training in their effects on cognitive decline among older adults. However, both the control and interval training groups demonstrated improvements in reaction time and accuracy on the Stroop color-word test, suggesting that exercise in general can show improvements in cognitive ability among older adults. Since both groups engaged in different forms of resistance training, future research should explore the effects of cardiovascular interventions in comparison to resistance training to determine the most effective modality for cognitive health. Future exercise training programs aiming for an improvement in cognitive performance should consider that these two modalities can show improvements in cognitive health. This is of special importance as adherence to exercise programming can be difficult for any individual, but especially older adults. Knowing the benefits that multiple types of exercise can have on physical and cognitive health broadens the range of choices individuals can make and simultaneously improve adherence to consistent intervention.

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