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Maintaining Physical Fitness and Function in Alzheimer's Disease: A Pilot Study

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Abstract

Background: Little is known about how aerobic exercise affects physical functioning in persons with Alzheimer's disease (AD). *Methods*: This pilot study used a 1-group repeated measures design to examine the feasibility and impact of a 6-month individualized moderate intensity cycling intervention on cardiorespiratory fitness and lower extremity function in 8 participants aged 81.4 ± 3.58. Cardiorespiratory fitness was measured using the shuttle walk and modified YMCA cycle ergometer tests, and lower extremity function was measured using the Short Physical Performance Battery (SPPB) at baseline, 3 months and 6 months. *Results*: The YMCA test showed a significant reduction in heart rate at stage 2 (103.4 vs 90.9 vs 91.6; $P = .01$), while no significant changes were observed in the shuttle walk and SPPB tests. *Conclusions*: Persons with AD are able to improve cardiorespiratory conditioning from aerobic exercise. Randomized, controlled trials are needed to confirm these findings. Implications for future research are detailed.

Keywords

dementia, aging, physical activity, physical function, exercise, cardiorespiratory fitness

Introduction

Little is known about the status of health-related physical fitness (ie, cardiorespiratory fitness) and lower extremity function in older adults with Alzheimer's disease (AD). Cardiorespiratory fitness and lower extremity function greatly affect activities of daily living (ADLs) in older adults and are amenable to aerobic exercise intervention.[1,2] Cardiorespiratory fitness, estimated by maximal or peak oxygen consumption ($VO_{2max\ or\ peak}$) is prone to age effect, declining substantially with aging at about 10% per decade after 20 years of age, and at an accelerated rate of decline of 15% to 22% per decade after 50 years of age for sedentary individuals.[2,3] Older adults often show cardiorespiratory fitness below the minimum level that is required for ADL independence.[4] The effect of AD on the level of VO_{2peak} is less known in older adults with AD. One study clustered older adults with Clinical Dementia Rating scale score of 0.5 (n = 23) and 1 (n = 8; age 75.8 ± 6.3 years) and showed that their VO_{2peak} of 19.8 mL/kg per min measured by maximal treadmill testing was similar to the VO_{2peak} of 21.2 mL/kg per min in 31 participants without early AD (age 76.1 ± 6.1 years).[5] Another study found 4 men with moderate-to-severe dementia (age 61-82 years) had VO_{2peak} ranging from 18.7 to 26.8 mL/kg per min using a submaximal cycle ergometer test.[6] In contrast, community-dwelling older adults showed a wide variability in lower extremity function measured by the Short Physical Performance Battery (SPPB), with those having greater lower extremity function being less likely to experience ADL disability and nursing home admission.[7]

Additionally, older adults with reduced cardiorespiratory fitness levels and lower extremity function tend to avoid exercise and become increasingly sedentary, which catalyzes a downward spiral of physical inactivity and further reduced cardiorespiratory fitness and lower extremity function.[1] Even in people without AD, only 31% of the individuals aged 65 to 74 years reported participating in 20 minutes of moderate physical activity 3 or more days a week, and only 16% reported 30 minutes of moderate activity 5 or more days a week.[8] Alzheimer's disease further potentiates the decline in physical activity because at least one study showed that older adults with early AD engaged in less habitual physical activity as measured by the Physical Activity scale (average score 77.8 compared to 129.1 in control; $P = .002$) and physical function as measured by the Physical Performance Test (26.7 vs 30.7 in control; $P = .002$).[5] Of those who developed dementia over a mean of 3.4-year follow-up, 3% of individuals with AD increased from no to much physical activity (vs 7% in those who did not develop dementia) and 15% of those with AD decreased from much to no physical activity (vs 8% in those who did not develop dementia).[9]

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Furthermore, older adults are fully capable of aerobic exercise intervention, forestall age-related decline in cardiorespiratory fitness, or experience an increase in cardiorespiratory fitness by 11% to 27% including those with mild cognitive impairment.[2,10-12] A meta-analysis involving 13 experimental studies also showed that older adults with cognitive impairment could improve cardiorespiratory fitness from aerobic exercise intervention.[13] However, a closer examination of the original studies included in this meta-analysis showed that the etiology for cognitive impairment ranged from psychiatric conditions to nonspecific dementias. When a more clearly defined AD sample was used, a meta-analysis by Forbes and colleagues (2008) found only 4 physical activity studies in persons with AD and dementia. None of the 4 studies measured cardiorespiratory fitness or lower extremity function. Hence, the purpose of this pilot study was to report the feasibility and impact of a 6-month, individualized, and supervised moderate intensity cycling intervention on cardiorespiratory fitness and lower extremity function in community-dwelling older adults with mild-to-moderate AD.

Methods

Design

This pilot study used a 1-group repeated measures design. The progressive aerobic exercise intervention involved 6 months of individualized cycling on a Precor recumbent stationary cycle (Precor Inc, Woodinville, Washington), 3 times a week, under the guidance and supervision of an exercise therapist. Cardiorespiratory fitness and lower extremity function was assessed at baseline and upon completion of 3-month and 6-month training. Participants were compensated $20 for completing each month of training. The study protocol was approved by the University of Minnesota's Institutional Review Board.

Setting

All study activities occurred at a retirement community in Saint Paul, Minnesota. Two Precor recumbent stationary cycles for exercise training were placed in the lounge of the assisted living building, while an upright Monark 828E ergomedic testing cycle (HealthCare International, Inc, Seattle, Washington) was available for performing the modified YMCA submaximal cycle ergometer test.

Sample

Participants were recruited through local newspaper and magazine advertisements, referral from senior housing, study flyer posting, and educational seminars conducted by the first author (F.Y.) at AD caregiver support groups from July 2008 to December 2009. The inclusion criteria were as follows: age >60 years; living in the community; a clinical AD diagnosis that was verified by the primary care provider; understand and speak English; and medical clearance from the primary care provider for participation in the aerobic exercise program. Exclusion criterai were (*a*) Mini-Mental State Examination (MMSE) scores <11 based on our previous findings that participants with moderate AD could improve their cardiorespiratory fitness from 2-month cycling, while participants with severe AD could not[6]; (*b*) contraindications to exercise training such as uncontrolled hypertension; (*c*) history, signs, and symptoms indicating unstable medical conditions that require further medical evaluation and treatment; and (*d*) inability to exercise using a cycle ergometer because of pain and discomfort. Of the 61 respondents, 48 individuals were excluded because they did not have an AD diagnosis, and 11 of the 13 respondents with a diagnosis of AD met the study eligibility criteria and were enrolled in the study. Reasons for excluding 2 individuals with AD were inability to cycle due to knee pain and uncontrolled hypertension.

Measures

One of the undergraduate research assistants (RAs) and the exercise therapist were trained as the data collectors by the first author (F.Y.) and an exercise physiologist consultant. The RAs collected demographic information at baseline, including age, gender, race/ethnicity, marital status, education, and living arrangement. The feasibility of the cycling program was analyzed at the end of the cycling program. Cardiorespiratory fitness was assessed by the exercise therapist and lower extremity function was assessed by the data collecting RAs at baseline and upon the completion of 3-month and 6-month training.

The feasibility of the cycling program includes the retention rate, exercise adherence rate, safety screening, and cost. The retention rate was calculated as the percentage of participants who completed the study divided by the total number of enrolled participants. The adherence rate was determined as the percentage of completed cycling sessions divided by 72 (the total number of prescribed sessions). Safety screening was assessed as the number of occurrence of adverse events from participating in the study. Cost referred to the estimate cost for conducting a cycling session.

Cardiorespiratory fitness was measured by the shuttle walk test and the modified YMCA submaximal cycle ergometer test. The shuttle walk test is a standardized, externally paced test that incorporates an incremental, progressive structure and stresses the individual to a symptom-limited maximal performance.[14] During the shuttle walk test, a pair of markers was placed on the floor 9 m apart, and participants were asked to walk a circuit around them while they were paced by a recording of beeps. The participant had to make each shuttle (1 way from 1 marker to another) to arrive at the time of the beep. If the participant arrived early, they were asked to wait for the beep before beginning the next shuttle. The intervals for beeps were initially long for each shuttle (20 seconds per 10-m shuttle), but got gradually shorter as the number of shuttles was increased. A triple beep sounded to alert participants that they needed to walk faster now. Since older adults with AD have trouble multitasking and remembering test instructions, the data collector also gave verbal instruction by saying "stop" when participants arrived at the marker before the beep, "go" when the single beep sounded, and "go and walk faster now" when the triple beep sounded. The test was terminated when the participant could not arrive at the marker at the time of the beep. Participants could use a walker or cane during the test. The total number of completed shuttles was recorded to derive the distance walked in meters, shortest time for completing a shuttle in seconds, and the highest speed during a shuttle (m/s) based on the shuttle walk's normative table.[14] The shuttle walk test is a reliable and valid test and showed strong correlation with VO_{2max} obtained during the conventional treadmill walking test in patients with chronic obstructive lung disease ($r = .88$).[14,15]

The modified YMCA submaximal cycle ergometer test was based on the YMCA submaximal cycle ergometer test that consists of 3 stages, with each stage lasting 3 minutes.[16] The YMCA submaximal cycle ergometer test was shown to be a valid test in comparison to the conventional treadmill walking test in 20 to 54 years old ($r = .79$).[17] In this study, the initial intensity and the intensity increment were reduced and only 2 stages were used for safety reasons because there was no electrocardiogram monitoring or cardiologist present. After 10 minutes of quiet sitting, resting heart rate (HR) was taken. Participants then mounted the Monark 828E upright cycle and started to cycle at 0.25 kilopounds (kp; = 75 kg; stage 1), which was increased to 0.50 kp after 3 minutes (stage 2) and followed by cooldown cycling at 0.25 kp. During the test, participants were asked to maintain a steady pace of 40 to 50 revolutions per minute. Heart rate was assessed using a wireless Polar F7 HR monitor (Polar Electro Finland Oy, Kempele, Finland) during the last 15 seconds of each stage. Blood pressure was measured after a 10-minute resting, during, and after testing.

Lower extremity function was measured with the SPPB.[7] The SPPB has 3 subscales (score for each subscale: 0-4): balance, gait speed, and sit-to-stand, and a total score range of 0 to 12, with higher score indicating better performance. During the balance test, participants were timed for their ability to perform 3 stands for 10 seconds: side-by-side, semi-tandem, and tandem stand. During the gait speed test, participants were timed for walking 4 m at usual speed twice. During the sit-to-stand test, participants were timed for performing 5 consecutive chair stands. The test–retest and inter-rater reliabilities of the SPPB are >0.90 in community-dwelling older adults.[7]

Procedures

Participant screening. Potential participants underwent a 3-step screening process to be qualified for study participation. First, an RA conducted a phone interview with the informant to elicit a potential participant's health history using a standard form. Individuals with a diagnosis of AD and without contraindications for exercise such as recent heart attack[18] were invited for an in-person screening. During this visit, research staff conducted the informed consent procedures. All prospective participants lacked understanding of the study based on a 10-item questionnaire (eg, what would you be asked to do by enrolling in the study; what are the potential risks of participating in the study); hence, participants gave assents while surrogates in the descending order of spouses and adult children provided written consents for participants. The first author (F.Y.) corroborated the health history and performed a neurologic examination and cardiac auscultation. The RA administered the MMSE. Finally, the participant's primary care physician was contacted to obtain medical clearance and verification of the participants' AD diagnosis.

Data collection. After a participant was enrolled, the RA administered the SPPB, while the exercise therapist administered the shuttle walk and the modified YMCA submaximal cycle ergometer test at baseline. Those tests were repeated after participants completed the 3 month and 6 month of aerobic exercise intervention by the same staff at about the same time of the day.

Aerobic exercise intervention. The aerobic exercise intervention was 6 months of supervised, individualized, moderate intensity cycling on Precor recumbent stationary cycles, 3 times a week. Our trained exercise therapist supervised 2 participants to exercise at each session. Participants' transportation to the training site was provided by research staff as needed. Since there is no published guideline about aerobic exercise intervention prescription and progression for older adults with AD, we used a subjective moderate intensity method to establish individualized moderate intensity. In each session, participants wore a wireless Polar HR monitor for continuous HR monitoring and did 5 to 10 minutes warm-up exercises before cycling at the target intensity and duration, which was followed by 5 to 10 minutes of cooldown exercises. After mounting the cycle, participants started to pedal at a low resistance and revolutions per minute (RPM) to raise their HR 5 to 10 bpm above their resting HR for 2 to 3 minutes. The resistance and RPM were alternatively increased every 2 to 3 minutes to increase their HR by 5 bpm until the participants reached subjective moderate intensity, that is, they could not tolerate more increase in resistance or RPM as evidenced by a 10-point perceived exertion scale of 5 to 6 (1-2 *not tired at all*, 3-4 *a little tired*, 5-6 *tired*, 7-8 *really tired*, and 9-10 *so tired, I cannot go anymore*), inability to speak a sentence without losing breath or signs and symptoms indicating overexertion (eg, skin color, sweat, and breathing). The HR at the subjective moderate intensity was documented as the target HR. Participants then cycled at the target HR for 10 to 15 minutes in week 1 and 15 to 20 minutes in weeks 2 and 3. At the end of week 3, subjective moderate intensity reflected by the perceived exertion rating, talk ability, signs, symptoms, resistance, RPM, and target HR was established for each participant. The duration at the subjective moderate intensity was progressively increased by 5 minutes from week 4 to week 12 based on the individual tolerance until the participants could continuously cycle for 45 minutes.

Data Management and Analysis

Data for this study were entered into a secure Web interface housed on secure servers operated by the university with checks during data entry to ensure data quality. Access to the system by user name and password required permission from the first author (F.Y.) and the database manager. After all data were entered, data were abstracted into a Microsoft Excel document, and read into the Statistical Programs for Social Sciences (SPSS 17.0). Descriptive statistics were performed first to further check data entry accuracy. Data were analyzed based on the 8 exercise completers only because the 3 participants who dropped out did not complete data collection at 3 and 6 months and because of the pilot nature of the study. Missing data and outliers were examined for meeting statistical assumptions of planned analysis. Histograms of the outcome data indicated no major deviation from a normal distribution. Interval data were presented as means, standard deviations of the mean/median, and ranges depending on their distributions. Categorical data were presented as counts and percentages.

Graphs were created for each of the outcome variables, over the 3 time points, with each subject plotted separately. These were examined for any indications of linear change signaling steady improvement or decline. This was not the case for most participants who showed varying trajectories over 6 months. Due to this, it was decided to analyze the data using repeated measures analysis of variance (RANOVA) with post hoc comparisons between time points using Tukey least square difference (LSD) which controls the overall α level at .05.

Table 1. Baseline Characteristics of the Study Sample (N = 8)

Variables	Means (SD), Range	Frequency (%)
Age	81.4 (3.58), 77-87	
Total years of education	12.6 (2.62), 8-17	
Gender		
Male		3 (37.5)
Female		5 (62.5)
Baseline Mini-Mental State Examination Scores	21.8 (5.1), 11-27	
Ethnicity non-Hispanic white		8 (100)
Marital status married		1 (12.5)
Divorced		1 (12.5)
Widow		4 (50.0)
Never married		1 (12.5)
Other		1 (12.5)
Living situation lived at home		
Lived alone in assisted living		5 (62.5)
Lived in a group home		3 (37.5)
Number of medical diagnoses except for AD	3.1 (1.5), 1-5	
Number of all prescribed and over-the-counter medications	5.5 (2.8), 2-11	
On β-blockers		3 (37.5)
On AD medications		7 (87.5)

Abbreviations: AD, Alzheimer's disease; SD, standard deviation.

Results

Description of the Sample

Of the 11 enrolled participants, 8 participants completed 6 months of aerobic exercise intervention and 3 participants dropped out. At baseline, the average age of the 8 participants was 81.4 years, ranging from 77 to 87 years with an average 12.6 years of education. Three participants were male and 5 lived alone in an assisted living facility. All participants were non-Hispanic white and 50% of the participants were widows (Table 1). In all, 3 participants had hypertension (2 were diagnosed more than 6 months ago and 1 diagnosed within the past 6 months), 2 had type II diabetes (1 diagnosed more than 6 months ago and 1 diagnosed within 6 months) but were not on diabetic medications, 1 had stroke 5 years ago, and 1 had transit ischemic attack 31 years ago. In total, 4 participants were on aricept alone, 1 on both memantine and aricept, 1 on both exelon and aricept, 1 on exelon alone, and 1 not on AD medications. Two participants were on atenolol and 1 on metoprolol. The demographics of the dropouts were similar to the sample except that higher percentages of the dropouts were married (66.7% vs 12.5%) and lived at home (66.7% vs 0%).

Feasibility of the cycling program. The retention rate for this study was 72.7%. One participant dropped out after completing 27 training sessions because of a nonstudy-related fall with hip fracture, which resulted in nursing home placement; a second participant dropped out after completing 12 training sessions due to bowel surgery with a subsequent fall and fracture during postoperative hospitalization; and a third participant dropped out after completing 16 training sessions due to exercise-related anxiety episodes. The adherence rate was 95.8% to 100%, that is, participants completed an average of 69.5 exercise sessions, ranging from 69 to 72 sessions. Safety screening was feasible because only 1 participant experienced exercise-related adverse events (anxiety episodes). The cost of cycling training was about $80 per session, including $35 for the exercise therapist, $30 for undergraduate students who provided transportation, and $15 for vehicle cost.

Cardiorespiratory Fitness

There were no significant differences in the average number of shuttles completed, distance walked for the test, the shortest time for completing a shuttle, and the highest speed during a shuttle from baseline to 3 months and 6 months (Table 2). The modified YMCA submaximal cycle ergometer test showed a trend for reduced HR at the same workload at stage 1 ($P = .06$) and HR was significantly reduced from baseline over time at stage 2 ($P = .01$), indicating a conditioning effect that the HR was raised less for the same intensity of workload likely due to increased stroke volume (Table 2).

Lower Extremity Function

The changes in the SPPB total score, balance, sit-to-stand, and gait speed subscale scores were not significant from baseline to 3 months and 6 months of training (Table 2).

Discussions

Although aerobic exercise intervention benefits older adults by reducing mortality and improving independence and quality of

Table 2. Changes in Physical Fitness and Function From Aerobic Training in Older Adults With Alzheimer's Disease (N = 8)[a]

Tests	Baseline, Mean ± SD	3-Month, Mean ± SD	6-Month, Mean ± SD	Overall *P* Value	Pairwise Significance
Shuttle walk test					
# of shuttles completed	10.9 ± 6.5	10.6 ± 8.1	11.8 ± 8.6	.87	
Distance walked (m)	108.8 ± 64.9	106.3 ± 80.7	117.5 ± 86.0	.87	
Shortest time for completing a shuttle (seconds)	12.8 ± 3.7	12.7 ± 3.9	12.9 ± 4.2	.96	
Highest speed during a shuttle (m/s)	0.84 ± 0.22	0.86 ± 0.26	0.86 ± 0.29	.93	
Modified YMCA cycle ergometer test					
Heart rate after 10-minute resting	78.3 ± 13.7	74.9 ± 7.9	78.1 ± 12.5	.22	
Heart rate at stage 1	98.9 ± 21.1	85.8 ± 12.1	87.3 ± 11.5	.06	
Heart rate at stage 2	103.4 ± 18.2	90.9 ± 11.3	91.6 ± 10.8	.01[b]	Baseline vs 3-month, Baseline vs 6-month
Heart rate at cooldown	94.9 ± 16.2	86.5 ± 15.3	89.8 ± 11.8	.85	
Short Physical Performance Battery (SPPB)					
SPPB total	8.0 ± 2.6	7.1 ± 2.4	7.3 ± 1.4	.37	
Balance subscale	2.4 ± 1.4	2.1 ± 1.1	2.1 ± 1.5	.72	
Gait speed subscale	3.3 ± 0.7	3.4 ± 0.7	3.5 ± 0.8	.50	
Actual time for 1st gait speed (seconds)	6.4 ± 1.6	5.9 ± 1.1	5.5 ± 1.4	.24	
Actual time for 2nd gait speed (seconds)	5.2 ± 1.4	5.0 ± 1.0	5.1 ± 1.8	.89	
Sit-to-stand subscale	2.4 ± 1.4	1.6 ± 1.3	1.6 ± 1.3	.29	
Actual time for sit-to-stand	13.3 ± 3.8	13.8 ± 2.3	15.0 ± 2.9	.28	

[a] Data were analyzed using repeated measures analysis of variance (RANOVA) with Tukey least significant difference (LSD) post hoc comparisons.
[b] $P < .05$.

life,[1,2] little is known about the impact of aerobic exercise intervention on cardiorespiratory fitness and lower extremity function in older adults with AD. A meta-analysis did report that aerobic exercise intervention improved cardiorespiratory fitness in older adults with cognitive impairment and dementia, but a closer examination showed that the etiology of cognitive impairment in the original study samples was related to different conditions such as psychiatric conditions.[13] Exercise studies in older adults with AD and other dementias, on the other hand, usually employed nonaerobic exercises (eg, strength and range of motion), low aerobic training duration and intensity, and lack of measures for cardiorespiratory fitness and lower extremity function.[19]

This study aimed to provide older adults with AD a structured, individualized, progressive, moderate-intensity exercise program for 6 months. The results of this study indicate that the 6-month cycling program was feasible and improved cardiorespiratory fitness in participants. There were no significant changes in the shuttle walk test over time which could be explained by several factors. The shuttle walk test gets progressively harder by requiring participants to walk faster and faster as the number of shuttles increases. Of the 8 participants, 3 (27.5%) were either physically unable and or not motivated to pick up their pace during the test. One of these participants who used a walker had difficulty picking up the pace. We had difficulty motivating 2 participants (1 woman used a walker and 1 man walked unaided) to walk faster than their casual pace. For example, the male participant kept stating that he was 80 years old and he was doing quite well for someone of his age. The female participant walked at her own usual speed despite encouragement and explanation for her to walk faster.

Anticipating the limitations of the shuttle walk test, we also used the modified YMCA submaximal cycle ergometer test. Our results demonstrated a clear aerobic exercise effect at stage 2 as evidenced by a reduced HR level at 3 and 6 months in comparison to baseline for the same intensity of workload. For this test, we reduced the first-stage intensity to 0.25 kp, the intensity increment to 0.25 kp, and the 3 stages to 2 in comparison to the original YMCA submaximal cycle ergometer test[16] based on 3 reasons. First, the original YMCA submaximal cycle ergometer test was mainly developed in young- to middle-aged population. Second, our previous pilot study showed that older adults with AD experienced considerable difficulty completing an original submaximal cycle ergometer test protocol because they were often too deconditioned to maintain the required cycling speed for an extended period of time.[6] Finally, we found that the intensity level of the original YMCA submaximal cycle ergometer test was not easy to do for even our staff who were physically fit. Even after these modifications to the YMCA submaximal cycle ergometer test, other unexpected difficulties emerged. This test was performed on an upright cycle, which was difficult for participants to get on and off. The cycle seat was uncomfortable to male participants or those who were overweight. We subsequently purchased the widest seat available, which somewhat improved comfort. Almost all participants preferred the recumbent cycles they used during exercise training.

Results from the SPPB test showed that the balance and sit–stand subscale scores suggested decline over time, while gait speed appeared to improve, but the standard deviations for those measures were large and none of the changes were statistically significant. These findings are similar to the previous reports that different modes of exercise affect different aspects of physical fitness and function, and aerobic exercise intervention affects mainly cardiorespiratory fitness.[20] It is plausible that a lower extremity resistance training program may result in greater improvement in lower extremity function as evident in older adults without dementia.[21] The dropout rate of 27.3% in our study is comparable to that of 0% to 37% in their age cohorts without dementia.[9] It was clear that 7 of the 8 participants really enjoyed their cycling (eg, stating they liked it and kept returning).

Together, the study findings might be attributable to the possibility that older adults with mild AD might have improved more in cardiorespiratory fitness, the shuttle walk test, and the SPPB than those with moderate AD. Hence, future adequately powered studies could examine the following hypotheses: (1) Aerobic exercise significantly improves cardiorespiratory fitness and lower extremity function in older adults with AD; and (2) Older adults with mild AD show greater improvements in cardiorespiratory fitness and lower extremity function from aerobic exercise than those with moderate AD. Furthermore, future studies should evaluate the cost-effectiveness of aerobic exercise interventions considering both the cost of delivering aerobic exercise and the savings from potentially delayed admission to nursing homes and reduced hospitalization and emergency care. We estimated that the average exercise session cost was about $80 including $35 exercise therapist time and $45 transportation cost. It is important to emphasize that our exercise therapist cost was considerably lower than the industrial average because we did not use a professional exercise therapist with the essential education and credentials due to our study budget limitations. The current cost for a professional exercise therapist ranges from $50 to $100/h depending on experience and location. The cost for cardiac rehabilitation based on the Center for Medicare and Medicaid Services reimbursement is $68.81/session for fiscal year 2011 excluding copayment. The cost of the aerobic exercise intervention might be reduced if the exercise therapist supervised more participants in a session or a partially supervised exercise intervention was used. We employed a fully supervised cycling intervention because we wanted to ensure cycling safety and develop a cycling program to fill the gap in the lack of guidelines about prescribing aerobic exercise to older adults with AD.

Findings from this study are limited by its small sample size, inability to control for potential covariates such as medical comorbidity, gender, age, baseline cognition, AD stage, and medication use, and lack of a control group. This study is further limited by measurement issues. Although we observed reductions in submaximal HR which infers less myocardial demands at the same level of intensity likely due to increases in stroke volume in the cycle ergometer test, the VO_{2peak} was not measured in our study. The cycle ergometer test has been shown to underestimate cardiorespiratory fitness due to muscle fatigue.[22] We indeed observed leg fatigue minutes into the test in a participant in our previous 4 case studies.[6] The measurement issues in the SPPB and the shuttle walk test might further account for the lack of improvements because of motivational, cognitive, and behavioral limitations in this population. It is likely that participants did increase their leg muscle strength over time, which was not captured by the shuttle walk test or the SPPB but contributed to the observed improved cardiorespiratory fitness. Future studies should examine better methods for assessing functional outcomes from aerobic exercise interventions. A strength of this study is that it provides preliminary data for the design of a future adequately powered, randomized controlled trial to examine the effect of aerobic exercise intervention on cardiorespiratory fitness and lower extremity function in older adults with AD.

Conclusions

Older adults with mild-to-moderate AD are capable of participating in aerobic exercise intervention and appear to improve their cardiorespiratory fitness, despite their cognitive symptoms.

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