Effect of aerobic exercise and cognitive training in elderly people at risk of Dementia through Telerehabilitation - A randomized control trial

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Abstract

Background

The individual benefits of aerobic exercise and cognitive training in reducing dementia risk are well-established; however, the combined effects of these interventions, particularly when delivered via telerehabilitation, require further investigation.

Objective

This study evaluated the effect of a 6-week telerehabilitation program combining aerobic exercise and customized cognitive training compared with customized cognitive training alone in elderly individuals at risk of dementia.

Methods

The randomized controlled trial involved 63 participants assigned to either a control group (n=31) receiving customized structured cognitive training or an experimental group (n=32) receiving combined aerobic and customized structured cognitive training. We assessed cardiovascular endurance using the 6-minute walk test (6MWT), and cognitive function using Mini-Mental State Examination (MMSE), the Addenbrooke's Cognitive Examination-III (ACE-III), and the Self-Administered Gerocognitive Examination (SAGE), and quality of life (QoL) using the WHOQoL questionnaire. Assessments were conducted at baseline, 6 weeks (post-training), and 8 weeks (follow-up)

Results

Of 87 individuals screened, totally 63 were randomized (mean [SD] age, 66.16 [7.81] years; [71%] female). Mean systolic blood pressure, resting heart rate (measured at baseline and at 1, 3, and 6 minutes) cognitive measure variable scores (MMSE, ACE, and SAGE), QoL scores was comparable between the control and experimental groups at any time point (baseline, 6 weeks, and 8 weeks) (p>0.05 for all). However, at 6 (post training) and 8th week follow-ups, diastolic blood pressure significantly lowered in experimental group compared to control group (p=0.015 and p=0.025, respectively).

Conclusion

Telerehabilitation combining aerobic exercise and customized cognitive training yielded comparable, clinically not significant improvements in cardiovascular fitness, cognition, and QoL in elderly individuals at risk of dementia compared to cognitive training alone. However, the combined intervention significantly reduced diastolic blood pressure, suggesting a potential cardiovascular benefit.

Keywords: Aerobic Exercise, Blood Pressure, Cognitive Training, Cognitive Function, Dementia, Elderly, Randomized Controlled Trial, Telerehabilitation

Introduction

Dementia, a cognitive disorder affecting an individual's memory, thinking, reasoning, and judgment, impairs the ability to perform daily tasks.[1] Worldwide, more than 55 million individuals are living with dementia, with nearly 10 million new cases diagnosed annually.[2] WHO estimates this number will reach 82 million by 2030 and 152 million by 2050.[2] Multiple factors, including aging, vascular conditions (e.g., diabetes, hypertension), neurodegenerative diseases (e.g., Alzheimer's), and viral infections (e.g., COVID-19), contribute to onset and progression of dementia.[3, 4]

Literature has shown that aerobic exercise training improves cognitive functions in individuals with dementia and reduces the risk of dementia progression.[5, 6] Some studies have also shown that cognitive training can slow the progressive decline in cognitive function in individuals at risk of dementia.[7] Cognitive training improve performance on specific tasks, with the assumption that these improvements will transfer to tasks requiring similar cognitive abilities.[8] Effective cognitive rehabilitation, therefore, requires continued training and regular follow-up to prevent age-related cognitive function decline in at-risk individuals.

Traditional cognitive or aerobic training involves intensive in-person sessions, but COVID-19 pandemic significantly disrupted global healthcare services.[9, 10] This disruption accelerated the adoption of telerehabilitation as a potential alternative to in-person treatments. Telerehabilitation uses various technologies, including real-time (synchronous) video and/or audio calls, or asynchronous e-visits, such as virtual check-ins, remote video evaluations, and exercise/educational applications.[11, 12] However, research on the use of telerehabilitation address both cognitive deficits and physical inactivity in elderly individuals at risk of dementia remains limited. This gap in knowledge necessitates further investigation into telerehabilitation protocols for this population.

While research has explored the individual benefits of aerobic exercise and cognitive training in individuals at risk of dementia, the combined effects of these interventions, particularly when delivered via telerehabilitation, are limited. Therefore, this study aims to evaluate the effect of a combined cognitive training and aerobic exercise program compared with a customized cognitive training program alone via telerehabilitation in this population.

Methods

Study Design

This two-year prospective, single center randomized controlled trial used a quantitative approach to evaluate the effects of aerobic exercise and cognitive training via telerehabilitation in an Indian elderly population at risk of dementia. Ethics approval was obtained from the institutional ethical review board. The study was conducted in accordance with the Declaration of Helsinki. All the selected participants provided written informed consent. Participants were recruited and screened based on predefined inclusion/exclusion criteria.

Study Population

Participants aged 60 to 75 years with controlled type II diabetes, hypertension, and obesity (Body mass index [BMI]: 25-34.5) were included in the study. Participants were included if they had a Mini-Mental State Examination (MMSE) score >26, were able to perform the 6-minute walk test (6MWT), and were able to use smartphones. Individuals with known cardiopulmonary or neuromuscular diseases, recent surgeries, conditions that could hamper aerobic training, or unwilling to participate were excluded.

Randomization and intervention

Of 87 individuals screened among this ten participates dropout after a week of training, another ten were irregular and 2 people expired another diagnosed with cancer. Eligible participants (N=63) were randomized to either an experimental group (n=32) or a control group (n=31) using a computer-generated random sequence. The experimental group received combined aerobic training and customized structured cognitive training, and the control group received the customised structured cognitive training for 6 weeks via telerehabilitation.

Assessments

Demographic data and vitals were recorded. All patients underwent a thorough clinical evaluation, including physical examination. Resting systolic blood pressure (SBP) and diastolic blood pressure (DBP) were taken using an automated device. The mean of 3 recordings, were taken 5 minutes apart. BMI was calculated from measured weight/measured height (kg/m^2).[13] Cardiac endurance and overall functional capacity were assessed using 6MWT.[14] Cognitive function was assessed using the MMSE, the Addenbrooke's Cognitive Examination-III (ACE-III), and the Self-Administered Gerocognitive Examination (SAGE). MMSE was administered to evaluate orientation, attention, memory, language, and visuospatial skills (scores range: 0-30, lower scores indicating greater impairment).[15] The ACE-III screening tool was administered to evaluate cognitive function including attention, memory, language, verbal fluency, and visuospatial abilities (scores range: 0-100, lower scores indicating greater cognitive impairment).[16] The SAGE, self-administered instrument was used to screen early signs of cognitive, memory or thinking impairments (maximum score: 22, lower scores suggesting greater cognitive decline).[17] QoL was assessed using 26-item WHOQoL-Brief questionnaire.[18] Each item was rated on a 5-point Likert scale (1 = not at all; 5 = completely), with higher scores indicating better QoL.[18] Assessments were conducted at baseline, 6 weeks (post-training), and 8 weeks (follow-up).

Statistical Analysis

Data was analyzed using SPSS software version 21. Categorical variables were presented as frequency tables, while continuous variables were expressed as Mean ± SD/ Median (Min, Max), depending on the distribution. Normality was assessed using Shapiro Wilk test and QQ plot. Between-group comparisons were performed using independent t-test (for normally distributed data) or Mann-Whitney U test (for non-normally distributed data). Within-group changes from baseline to each follow-up time point were assessed using paired samples t-tests (for normally distributed data) or Wilcoxon signed-rank tests (for non-normally distributed data). The Chi-square test was performed to find the association between categorical variables and groups. The intervention effect was analyzed using mean (SD) for within-group differences and mean (95% confidence interval) for between-group differences. P-value less than or equal to 0.05 indicates statistical significance.

Results

Of 87 individuals screened for eligibility, 63 were randomized (mean [SD] age, 66.16 [7.81] years; [71%] female). Baseline characteristics were similar between the control and experimental group. No significant difference in age, height, weight was found between the treatment and control groups (p>0.05 for all), and no significant association was found between gender and treatment type (Table 1).

Table 1: Demographic data in control and experimental groups

Variable	**Control, n=31**	**Experimental, n=32**	**p-value**
Age (years)	66.16 ± 7.81	66.16 ± 7.81	0.189
Gender			
Female	22 (71%)	20 (62.5%)	0.475
Male	9 (29%)	12 (37.5%)	
Height (cms)	153.35 ± 8.29	156.4 ± 14.16	0.161
Weight (kgs)	61.22 ± 11.7	61.2 ± 7.48	0.994

Baseline SBP and DBP measurements did not differ significantly between the control and experimental groups (p>0.05 for both). However, at the 6 week post training and 8th week follow-up, the experimental group showed a significant reduction in mean DBP compared to the control group (p=0.015 and p=0.025, respectively). No significant differences were found for SBP at any time point (Table 2).

Table 2. Comparison of clinical characteristics in Control and Experimental Groups at Baseline and Follow-up

Variable	**Control, n = 31**	**Experimental, n = 32**	**p-value**
SBP (Initial)	141.48 ± 17.74	137.62 ± 14.15	0.561

DBP (Initial)	83.29 ± 7.07	80.75 ± 5.78	0.054
SBP (at 6 weeks)	137.58 ± 15.71	135.15 ± 12.97	0.764
DBP (at 6 weeks)	83.35 ± 5.09	79.25 ± 6.21	**0.015***
SBP (Follow up at 8 weeks)	136.87 ± 15.58	133.21 ± 12.31	0.502
DBP (Follow up at 8 weeks)	82.9 ± 5.79	78.75 ± 6.13	**0.025***
BMI (Initial)			
<18.5 (Underweight)	0	0	0.207
18.5-24.9 (Normal)	13 (41.9%)	20 (62.5%)	
25-29.9 (Overweight)	13 (41.9%)	10 (31.3%)	
>30 (Obese)	5 (16.1%)	2 (6.3%)	
Mean ± SD	25.75 ± 3.78	24.74 ± 5.23	0.118
BMI (Post training at 6 weeks)			
<18.5 (Underweight)	0	0	0.143
18.5-24.9 (Normal)	13 (41.9%)	21 (65.6%)	
25-29.9 (Overweight)	13 (41.9%)	9 (28.1%)	
>30 (Obese)	5 (16.1%)	2 (6.3%)	
Mean ± SD	25.63 ± 3.75	24.42 ± 5.2	0.081
BMI (Follow up at 8 weeks)			
<18.5 (Underweight)	0	0	0.143
18.5-24.9 (Normal)	13 (41.9%)	21 (65.6%)	
25-29.9 (Overweight)	13 (41.9%)	9 (28.1%)	
>30 (Obese)	5 (16.1%)	2 (6.3%)	

Mean ± SD	25.6 ± 3.75	24.39 ± 5.2	0.083

**p* < 0.05. BP: Blood pressure; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; SD: Standard deviation; BMI: Body Mass Index. Data are presented as mean ± SD and median (minimum, maximum).*

Table 3 shows resting heart rate measured at baseline and at 1, 3, and 6 minutes did not differ significantly between the control and experimental groups at any time point (baseline, 6 weeks, and 8 weeks).

Table 3. Comparison of Changes in Cardiovascular Fitness Measures Between Control and Experimental Groups Over Time

Variable	**Control, n = 31**	**Experimental, n = 32**	**p-value**
RHR (Initial)	73.67 ± 7.41	73.06 ± 8.21	0.659
RHR (at 6 weeks)	73.25 ± 7.26	72.25 ± 7	0.696
RHR (Follow up at 8 weeks)	72.35 ± 7.16	71.93 ± 6.57	0.865
RHR 1 min (initial)	75.64 ± 9.26	78.09 ± 10.84	0.447
1 min (at 6 weeks)	75.35 ± 8.96	77.09 ± 10.01	0.423
1 min (Follow up at 8 weeks)	75.22 ± 9.22	77.06 ± 8.99	0.238
RHR 3 min (initial)	77.45 ± 10.46	80.25 ± 11.33	0.337
3 min (at 6 weeks)	77.35 ± 10.28	79.03 ± 10.29	0.373
3 min (Follow up at 8 weeks)	77.12 ± 10.29	78.62 ± 8.79	0.280

RHR 6 min (initial)	81.96 ± 18.1	83.4 ± 12.04	0.230
6 min (at 6 weeks)	81.38 ± 16.85	81.96 ± 10.64	0.204
6 min (Follow up at 8 weeks)	80.38 ± 16.26	81.65 ± 9.58	0.147

RHR, resting heart rate

Table 4 shows MMSE, ACE, and SAGE scores did not differ significantly between the control and experimental groups at any time point (baseline, 6 weeks, and 8 weeks).

Table 4. Comparison of Cognitive Function Scores Between Control and Experimental Groups at Baseline and Follow-up

Variable	**Control, n = 31**	**Experimental, n = 32**	p-value
MMSE (Initial)	24.9 ± 3.17	23.64 ± 3.56	0.123
MMSE (at 6 weeks)	26.48 ± 2.88	25.62 ± 4.06	0.589
MMSE (Follow up at 8 weeks)	26.9 ± 2.66	25.96 ± 4.14	0.483
ACE (Initial)	76.61 ± 14.41	78.68 ± 13.89	0.575
ACE (at 6 weeks)	79.06 ± 14.44	82.37 ± 14.11	0.362
ACE (Follow up at 8 weeks)	79.8 ± 14.49	83.34 ± 14.02	0.298
SAGE (Initial)	17.77 ± 1.99	17.58 ± 1.86	0.343
SAGE (at 6 weeks)	18.9 ± 1.97	18.65 ± 2.59)	0.944

SAGE (Follow up at 8 weeks)	19.25 ± 1.78	19.16 ± 2.4	0.992

MMSE, Mini-Mental State Examination (MMSE), ACE, Addenbrooke's Cognitive Examination, SAGE, Self-Administered Gerocognitive Examination

Table 5 shows quality-of-life scores did not differ significantly between the control and experimental groups at any time point (baseline, 6 weeks, and 8 weeks).

Table 5. Comparison of WHO quality-of-life-BREF Scores Between Control and Experimental Groups at Baseline and Follow-up

Variable	**Control, n = 31**	**Experimental, n = 32**	**p-value**
Initial	109.22 ± 21.9	100.18 ± 24.53	0.092
Post training 6 weeks	111.45 ± 22.18	102.25 ± 24.69	0.089
Follow up at 8 weeks	112.22 ± 21.65	103.18 ± 24.5	0.089

Discussion

Customized cognitive training and aerobic training in the comfort of their own home or day care, enhance rehabilitation. This trial evaluated a 6-week telerehabilitation program combining aerobic exercise and customized cognitive training in elderly individuals at risk of dementia. Participants in both the combined program and the customized cognitive training program alone experienced similar improvements in clinical characteristics (SBP and BMI), cognitive function, and QoL. However, participants only in the combined intervention group experienced a slight significant reduction in mean DBP at both the 6th week of post operation and 8-week follow-ups.

The slight significant reduction in DBP (2mm of Hg reduction) observed in the combined intervention group highlights the specific cardiovascular benefits of incorporating aerobic exercise via tele-rehabilitation for individuals at risk of dementia. This finding aligns with previous research demonstrating that 6 months of regular aerobic fitness training can increase brain volume in both gray and white matter regions (areas crucial for cognitive functions like memory and executive control) in elderly individuals. This suggests a strong link between cardiovascular health and central nervous system integrity, as improved blood flow and oxygen delivery to the brain can support neuronal health and function.[19] A prospective cohort study from the Norwegian Trøndelag Health Study (HUNT) also reported that improving blood pressure and cardiorespiratory fitness over time reduced dementia risk in adults irrespective of age.[20]

While both groups in our study showed slight improvements in cardiovascular function, cognitive function and quality of life, these changes were not clinically significant. However, this result does not preclude the possibility of a synergistic effect of combining aerobic exercise and cognitive training, and future studies should include a group receiving aerobic exercise alone to compare its effects to those of the combined intervention and customized cognitive training. Supporting the potential benefits of combined interventions, Park et al. found that patients with mild cognitive impairment who participated in a combined program (physical activity, aerobic exercise, and cognitive exercise) showed improved physical fitness, physical activity, executive function test, and working memory compared to a control group.[21] The SYNERGIC Trial showed greater improvements in global cognition (including memory, attention, word recognition, and orientation) in individuals with mild cognitive impairment who participated in combined aerobic-resistance exercise with sequential cognitive training compared to exercise alone.[22]

Studies suggest telerehabilitation as a viable alternative option to in-person interventions. In a study of 40 participants with brain injury, researchers found no significant difference in outcomes between telerehabilitation and in-person visits, supporting the feasibility of remote interventions.[23] Similarly, a US study of individuals with mild cognitive impairment (n=49) observed comparable improvements in memory, language and visuo-constructional abilities following both face-to-face virtual reality rehabilitation and in-person cognitive treatment, further supporting the effectiveness of telerehabilitation in cognitive rehabilitation.[7] This study also underscores the potential of telerehabilitation in expanding access to cognitive rehabilitation, particularly for individuals facing barriers such as geographical distance, transport difficulties, or limited local services.

Our findings suggest that a combined telerehabilitation approach incorporating aerobic exercise may be beneficial in managing cardiovascular risk factors, which could reduce dementia progression. However, we acknowledge that our study has few potential limitations. First, the sample size was small, limits the generalizability of study findings and might have contributed to lack of clinically significant difference in few outcomes. Replicating the study with a larger group of elderly individuals at risk of dementia would be beneficial. Second, adoption of longer follow-up in future studies would be beneficial to assess the long-term effects of the treatments. Finally, our study findings are insufficient to draw firm conclusions on the effects of interventions on functional activities or quality of life. Future studies with well-designed methodologies such as crossover design allow each participant to experience both the interventions minimizing confounding variables related to inter-individual differences and providing a more precise estimate of the interventions' impact.

Conclusion

This trial demonstrated that a telerehabilitation program combining aerobic exercise and customized cognitive training resulted in comparable, though not clinically significant, improvements in cardiovascular fitness, cognitive function, and quality of life in elderly individuals at risk of dementia compared to customized cognitive training alone. Notably, the combined intervention significantly lowered diastolic blood pressure, suggesting a potential benefit for cardiovascular health.

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