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The Mental Activity and eXercise (MAX) Trial: Effects on Physical Function and Quality of Life among Older Adults with Cognitive Complaints

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Abstract

Background—Older adults with cognitive complaints are vulnerable to dementia, physical impairments, and poor quality of life. Exercise and mental activity may improve physical function and health-related quality of life (HRQOL) but combinations have not been investigated systematically. The Mental Activity and eXercise (MAX) trial found that mental activity plus exercise over 12 weeks improved cognitive function (primary outcome) in sedentary older adults with cognitive complaints.

Objective—To investigate the effects of combinations of two mental activity and exercise programs on physical function and HRQOL (secondary outcomes).

Methods—Participants (n=126, age 73±6 years, 65% women) were randomized to 12wks of exercise (aerobic exercise or stretching/toning, 3×60min/wk) plus mental activity (computer-based cognitive training or educational DVDs, 3×60min/wk) using a factorial design. Assessments included the Senior Fitness Test (physical function), Short Form-12 physical and mental sub-scales (HRQOL), and CHAMPS questionnaire (physical activity).

Results—There were no differences between groups at baseline (p>0.05). We observed improvements over time in most physical function measures [chair stands (p-for-time=0.001), arm curls (p-for-time<0.001), step test (p-for-time=0.003), sit & reach (p-for-time=0.01), and back

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scratch (p-for-time=0.04)] and in physical HRQOL (p-for-time=0.04). There were no differences in change between groups (group*time p>0.05). Changes in most physical function measures and physical HRQOL correlated with physical activity changes.

Conclusion—Combined mental activity and exercise interventions of various types can improve both physical function and physical HRQOL among sedentary older adults with cognitive complaints. Exercise control group design should be carefully considered as even light exercise may induce benefits in vulnerable older adults.

Keywords

Older Adults; Exercise; Cognitive Training; Randomized Controlled Trial; Physical Function; Quality of Life

INTRODUCTION

Over half of older adults subjectively report cognitive deterioration (cognitive complaints) (1;2). Cognitive complaints may represent a very early state of cognitive impairment, more sensitive than most neuropsychological tests (3–5). Older adults with cognitive complaints and mild impairment have greater brain atrophy and greater risk of dementia (4–7). They also have poorer physical function and functional abilities compared to cognitively normal populations and report poorer quality of life (8–11). Thus, people with cognitive complaints may be a vulnerable population appropriate for interventions with the goal of improving physical function and quality of life, in addition to cognitive function.

Increasing evidence supports exercise and mental activity as strategies to improve cognitive function among people with and without cognitive complaints or impairment (12). These interventions may also improve the health and well-being of older adults more broadly. The evidence for exercise is more substantial. Exercise is recommended by the American College of Sports Medicine to improve functional independence and quality of life and to reduce the risk of chronic disease (13). Exercise training improves many elements of physical wellness among older adults, including aerobic fitness and functional mobility and reduces the risk of chronic disease (14;15). Exercise may also improve quality of life—especially health-related quality of life (HRQOL)—among older adults (16;17). Preliminary evidence also supports mental activity to improve physical outcomes and HRQOL (18;19). Combining mental activity with exercise may augment benefits to physical function (especially gait speed, agility, and balance) (18;19). Even mental activity alone may improve physical function and quality of life among older adults (20;21).

To our knowledge, the Mental Activity and eXercise (MAX) trial is the first trial to investigate the combined effects of exercise plus mental activity on physical function and HRQOL (as secondary outcomes) using a factorial design. The primary results of the MAX Trial were previously published and indicated that exercise plus mental activity improved cognitive function over 12 weeks among inactive older adults with cognitive complaints, with no significant differences between groups (22). The objective of these analyses was to examine the combined effects of exercise plus mental activity on physical function and HRQOL among older adults with cognitive complaints.

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MATERIALS AND METHODS

This is an analysis of the MAX Trial. Detailed study procedures are described elsewhere (22). In brief, 126 inactive older adults with cognitive complaints were block randomized to 12-weeks of exercise (aerobic exercise intervention or stretching and toning control) plus 12-weeks of mental activity (computer training intervention or educational DVD control) using a factorial design. Participants had to be 65 years or older, report a recent decline in memory or thinking, and not currently be engaged in aerobic exercise or intensive computer training (≤2 days/week, ≤30 minutes/session in the past 3 months). People with dementia or other major central nervous system disorders, psychiatric disorder, heart or lung disease, or illness or condition that would make participation dangerous were excluded. The research protocol was approved by the Committee on Human Research at the University of California, San Francisco and the San Francisco Veterans Affairs Medical Center Research and Development Committee.

Interventions

Physical Activity—Both the exercise intervention (EX-I) and exercise control (EX-C) groups attended study-specific group exercise classes at a local YMCA for 60 minutes per day, 3 days per week for 12 weeks. The same certified exercise instructor, who had prior experience conducting exercise classes for older adults, taught the EX-I and EX-C classes. There were a maximum of 12 participants per class at a time. The exercise instructor recorded daily attendance. Compliance and adverse events were monitored using weekly journals and biweekly telephone check-ins.

The EX-I class consisted of 10 minutes warm-up, 30 minutes aerobic exercise, 5 minutes cool-down, 10 minutes strength training, and 5 minutes stretching/relaxation. Heart rate was recorded by participants through 10-second wrist or neck pulse at the beginning, peak, and end of the class with a target heart rate of 60–75% of maximum for age. The EX-C class consisted of 10 minutes warm-up, 30 minutes stretching and toning, 10 minutes strength training, and 10 minutes relaxation. Heart rate was also recorded in EX-C group but with a goal of not raising heart rate above resting levels.

Mental Activity—Both mental activity intervention (MA-I) and mental activity control (MA-C) groups completed their assigned mental activities at home on a computer for 60 minutes per day, 3 days per week for 12 weeks. Compliance and adverse events were monitored using weekly journals and biweekly telephone check-ins.

The MA-I group performed games designed to increase speed and accuracy of visual and auditory processing (Posit Science, San Francisco, CA). Games focusing on visual tasks included determining the direction of visual sweeps, identifying bird pairs, tracking the location of moving gems, and identifying targets in peripheral vision. Games focusing on auditory tasks included determining the direction of auditory sweeps, distinguishing between similar sounds, following verbal instructions, and answering questions about verbal stories. The MA-C group watched DVDs of educational lectures on art, history, and science. After each lecture, participants were asked 6 paper-based, multiple-choice or short answer questions about the material covered in the DVD presentation.

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Measures

Data were collected at baseline and following the 12-week intervention period. Research staff that assessed participants at baseline and follow up were blinded to participant group assignment.

Outcomes—Physical function was measured using the Senior Fitness Test (23). The Senior Fitness Test includes measures of lower body strength (chair stands in 30 seconds), upper body strength (arm curls with 5lbs for women and 8lbs for men), aerobic endurance (high knee steps in 2 minutes), lower body flexibility (sit and reach), upper body flexibility (back scratch test), and agility (timed up and go test) (23).

HRQOL was measured using the Short Form-12 health survey (24). The Short Form-12 includes two sub-scores: physical component summary and mental component summary, which reflect physical and mental HRQOL.

Physical Activity—Participation in physical activities was reported using the Community Healthy Activities Model Program for Seniors (CHAMPS) questionnaire (25). The CHAMPS questionnaire is a comprehensive 41-item self-administered questionnaire that assesses the frequency and duration of various physical activities frequently performed by older adults. Participants report the frequency and duration of activities in a typical week during the past four weeks. We derived frequency of exercise-related activity (times per week) using recommended formulas (25).

Other measures—Demographic data included self-reported age, sex, years of education, race/ethnicity and income. Smoking status was classified as never, former or current. History of comorbid medical conditions was assessed based on self-report ("Has a doctor ever told you that you had…"). Global cognitive function was measured at baseline using the Modified Mini-Mental State Examination (26). Mood was assessed using the Geriatric Depression Scale (27).

Statistical Analysis

All analyses were completed on an intent-to-treat basis. Baseline characteristics of study participants were compared between groups using analysis of variance (ANOVA) for continuous variables and chi-square analysis for categorical variables. Measures of adherence (number of exercise classes attended, heart rate in exercise sessions (beats per 10s), and minutes of mental activity training sessions completed) were evaluated using ANOVA.

Outcomes were analyzed using linear mixed models with terms for group (to test for differences between groups), time (to assess for overall changes over time) and group*time (to assess for differences between groups in change over time). In addition, we used Spearman correlations to examine whether change in frequency of physical activity was associated with changes in physical function and HRQOL. Statistical analyses were performed using SAS 9.2 or Stata 12.1.

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RESULTS

Study flow was previously described in detail (22). In brief, 126 individuals were enrolled to the MAX Trial with 32 randomized to the MA-I/EX-I group, 31 to the MA-I/EX-C group, 31 to the MA-C/EX-I group, and 32 to the MA-C/EX-C group. Of the 26 (21%) participants who withdrew from the study, 16 withdrew due to illness or physical inability to complete study procedures and 9 withdrew due to adverse events that were either possibly or probably related to study procedures but recovered without residual problems. The baseline characteristics of study participants are detailed in Table 1. Participants who dropped out were similar in demographics and co-morbidities (p>0.12) but had worse physical function (chair stands: 8.9 vs 10.8, p=0.3; steps in 2 minutes: 61.0 vs. 74.3, p=0.02; other measures, p>0.05) and physical HRQOL (physical: 42.7 vs. 48.2, p=0.01) than participants who completed the study.

Adherence

Participants attended an average of 27.75 (SD 8.1) of 36 exercise classes. Attendance at exercise sessions was similar across groups (p=0.15). Maximum heart rate (per 10s) during the exercise sessions varied by group, as expected, where those in EX-I (combined with either MA-I or MA-C, 15.1 (2.3) and 16.5 (2.6) respectively) had greater maximum heart rate than those in EX-C (13.5 (2.2) and 13.5 (1.9) respectively) (p<0.001). Maximum heart rate did not vary by mental activity group (p=0.97). In addition, participants completed 1905.4 (672.8) of 2160 minutes of mental activity training on average. Minutes completed did not differ between groups (p=0.82).

Physical Function

Physical function was similar across groups at baseline (Figure 1, p>0.05). Study participants experienced significant improvement in most measures of physical function (average improvement chair stands: 10.4(4.0) to 11.8 (4.6), p=0.001; arm curls: 12.1 (4.6) to 14.3 (4.2), p-for-time<0.001; steps in 2 minutes: 71.6(24.8) to 76.0 (26.1), p-for-time=0.003; sit and reach: −1.3 (4.5) to −0.6 (4.6), p-for-time=0.014; back scratch: −4.3 (5.1) to −4.0 (5.3), p-for-time=0.035) between baseline and follow-up. There was no change in the timed up-and-go test (average change: 6.9 (2.8) to 6.7 (2.5), p-for-time=0.35). In addition, there were no significant differences between groups over time for any measure of physical function (all group*time p>0.05). Change in physical function measures by randomization group is displayed in Figures 1 A–F.

Change in Health-Related Quality of Life

Both physical and mental HRQOL were similar between groups at baseline (Figure 2, p>0.05). The study sample as a whole improved significantly in physical HRQOL (46.5 (9.5) to 47.7 (9.7), p-for-time=0.04) but not in mental HRQOL (52.1 (8.3) to 52.1 (9.0), p-for-time=0.50). In addition, there were no significant differences between groups over time (Figures 2 A–B).

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Association between Change in Physical Activity, Physical Function, and HRQOL

Physical activity frequency increased significantly from baseline to post-intervention (16.2 (9.3) to 21.4 (12.9), paired t-test p <0.001). The change in the frequency of physical activity was correlated with greater improvement in chair stands, arm curls, 2-minute step test, and PCS-12, but not with other outcomes (Table 2). The correlation with change in weekly physical activity frequency was highest for chair stands (r=0.27, p=0.001) and physical HRQOL (r=0.26, p=0.002).

DISCUSSION

In this 12-week randomized controlled trial with a factorial design, we compared the effects of different combinations of exercise and mental activity interventions on physical function and HRQOL. Participants improved in most measures of physical function and in physical HRQOL over 12 weeks, but there were no significant differences in the magnitude of change between groups. This suggests that exercise and mental activity interventions of varying design may equally benefit physical function and physical HRQOL among inactive older adults with cognitive complaints. Of note, participants also reported a significant increase in weekly frequency of physical activity over the study. The magnitude of increase in physical activity was related to the magnitude of improvement in physical function and physical HRQOL, indicating integrating exercise into daily life may be most important.

Poor physical function is an independent risk factor for future dementia and is also common among people with cognitive complaints or mild cognitive impairment (28–31). Poor physical function—particularly poor strength—increases the likelihood of functional dependence, (32;33), which is common among people with cognitive impairment. In this study, we found that the two exercise programs—aerobic exercise and stretching and toning—similarly improved several components of physical function (including aerobic fitness, strength, and flexibility) among inactive older adults with cognitive complaints. Aerobic exercise was not superior to stretching and toning for any of our physical outcomes. This is in contrast to prior studies that found significantly greater improvement in physical fitness among people who completed an aerobic exercise intervention compared to a stretching and toning control (34–36). The 2-minute step test may be equally influenced by aerobic exercise and toning interventions than tests of maximum aerobic capacity (VO_2max) or 6-minute walk distance, used in prior studies. Indeed, lower body strength, which influences performance on step tests more than 6-minute walk distance, likely improved at least in part due to the strength training included in both groups (37). Alternatively, it may be that our aerobic exercise intervention was not sufficiently intense to elicit changes greater than those in the stretching and toning control. While the peak HR (approximately 95bpm, corresponding to 61% of age-adjusted estimated maximum HR) was within the target range (60–75%), the magnitude of differences between groups may not be sufficient to induce significantly greater improvements in physical function. Finally, it is possible any added benefits of aerobic exercise versus stretching and toning may need more than 12 weeks to manifest.

Aerobic exercise is also associated with improved quality of life, specifically HRQOL, in some but not all prior studies (16;17;38). Evidence for a positive relationship between

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exercise and quality of life is most consistent in cross-sectional studies, where the causality is unclear (17). In the current study, physical HRQOL improved across all groups. This is in line with prior work that suggests there is a relationship between the intensity of exercise interventions and the magnitude of change in HRQOL in randomized and non-randomized controlled trials (17). Significant results have been observed primarily when participants were re-grouped post hoc (17). Similarly, in our study, people who had greater increase in the weekly frequency of physical activity (reported with the CHAMPS questionnaire) had greater increase in physical HRQOL, though there was no differences by intervention groups. This suggests that the overall change in total daily physical activity may be as or more important as the exercise performed during the intervention. Alternatively, it is possible that those who felt they benefited from the intervention more, and thus experienced greater improvement in physical HRQOL, may also have been more motivated to also increase physical activity frequency.

Improvements in physical function and physical HRQOL were also similar across the mental activity intervention and control groups. Using a similar intervention, six-weeks of home-based computer training was associated with an improvement in gait speed in one study (20). However, this feasibility study did not use a control group so any computer training might have elicited similar results, as in the current study. Other studies that found that mental activity and exercise improved physical function used more cognitively demanding measures of physical function, such as gait with or without a dual-task (18;21). It is likely that improved cognitive control during physical assessments at least partially accounts for the changes observed with activity. It may be that the measures of physical function employed in this study were not sufficiently cognitively demanding to be sensitive to the effects of mental activity. Alternatively, it is possible that cognitive training and educational videos had similar effects on physical outcomes among older adults with cognitive complaints.

One of the challenges to designing behavioral interventions is selection of appropriate control groups. Control group designs employed for exercise interventions include a stretching and toning group, an educational group, or a no-contact group. The most conservative option, a stretching and toning control (used here) integrates blinding to group allocation but may be sufficiently ‘active’ to induce significant improvements to physical function, among other outcomes. In addition, inclusion of strength training in the intervention and control groups in the MAX trial may have further contributed to the similarity of effects between groups. The control for the mental activity intervention was also active—educational videos on a computer. It is likely that some of our participants had little exposure to computers prior to the study so the control condition might have been sufficiently stimulating to have induced independent effects. The use of passive controls in addition to active controls may help to understand the benefits associated with interventions as opposed to repeated testing. The challenge of recruiting to a passive control could be reduced if participants in this group are given delayed access to the intervention. Control group selection should be given careful consideration in all future exercise and mental activity trials.

Our study has strengths but also some weaknesses. The primary strength of this study is its 2×2 factorial design, which allowed us to compare the effects of different combinations of

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mental activity and exercise. We included active controls for both conditions, which allowed us to control for the benefits due to social stimulation (exercise) and computer training (mental activity). However, even very low intensity interventions may elicit improvements among physically and mentally inactive older adults (39;40). As a result, future studies should consider including active and passive control groups. In addition, our study population included individuals with cognitive complaints who were ethnically diverse. This study also has several limitations. First, the study included a relatively short intervention period of 12 weeks. It is possible that effects by group may have diverged after 12-weeks. Second, although ethnically diverse, our group was highly educated so our results may not generalize broadly. Third, both EX-I and EX-C were group classes so it is unclear whether similar benefits could be achieved with individual or home-based exercise. Fourth, though we used a validated measure of physical function, peak aerobic capacity (arguably the gold standard measure of physical fitness) was not included. Finally, the drop of the studies had worse physical function and HRQOL at baseline. Additional strategies may be needed to retain those who are worse off at baseline.

Conclusions

Combinations of mental activity and exercise improved physical function as well as physical HRQOL among inactive older adults with cognitive complaints over 12 weeks. These findings suggest that, a variety of exercise and mental activities can have a significant and rapid improvement on physical wellbeing among older adults with cognitive complaints. Further work should examine these interventions with different group designs in order to understand better the effects of physical, mental and social activities, both alone and in combination.

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Glossary

ANOVA	Analysis of variance
CHAMPS questionnaire	Community Healthy Activities Model Program for Seniors
EX-C	exercise control
EX-I	exercise intervention

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HRQOL	health-related quality of life
MA-C	mental activity control
MA-I	mental activity intervention
MAX trial	Mental Activity and eXercise

References

1. Slavin MJ, Brodaty H, Kochan NA, Crawford JD, Trollor JN, Draper B, et al. Prevalence and predictors of "subjective cognitive complaints" in the Sydney Memory and Ageing Study. Am J Geriatr Psychiatry. 2010 Aug; 18(8):701–10. [PubMed: 21491631]
2. Westoby CJ, Mallen CD, Thomas E. Cognitive complaints in a general population of older adults: prevalence, association with pain and the influence of concurrent affective disorders. Eur J Pain. 2009 Oct; 13(9):970–6. [PubMed: 19110455]
3. Haley AP, Hoth KF, Gunstad J, Paul RH, Jefferson AL, Tate DF, et al. Subjective cognitive complaints relate to white matter hyperintensities and future cognitive decline in patients with cardiovascular disease. Am J Geriatr Psychiatry. 2009 Nov; 17(11):976–85. [PubMed: 20104055]
4. Saykin AJ, Wishart HA, Rabin LA, Santulli RB, Flashman LA, West JD, et al. Older adults with cognitive complaints show brain atrophy similar to that of amnestic MCI. Neurology. 2006 Sep 12; 67(5):834–42. [PubMed: 16966547]
5. Wang PJ, Saykin AJ, Flashman LA, Wishart HA, Rabin LA, Santulli RB, et al. Regionally specific atrophy of the corpus callosum in AD, MCI and cognitive complaints. Neurobiol Aging. 2006 Nov; 27(11):1613–7. [PubMed: 16271806]
6. Mitchell AJ, Shiri-Feshki M. Rate of progression of mild cognitive impairment to dementia--meta-analysis of 41 robust inception cohort studies. Acta Psychiatr Scand. 2009 Apr; 119(4):252–65. [PubMed: 19236314]
7. Wang L, van BG, Crane PK, Kukull WA, Bowen JD, McCormick WC, et al. Subjective memory deterioration and future dementia in people aged 65 and older. J Am Geriatr Soc. 2004 Dec; 52(12): 2045–51. [PubMed: 15571540]
8. Auyeung TW, Kwok T, Lee J, Leung PC, Leung J, Woo J. Functional decline in cognitive impairment--the relationship between physical and cognitive function. 2008:167–73. 2008/09/12.
9. Teng E, Tassniyom K, Lu PH. Reduced Quality-of-Life Ratings in Mild Cognitive Impairment: Analyses of Subject and Informant Responses. Am J Geriatr Psychiatry. 2012 Dec; 20(12):1016–25. [PubMed: 23018474]
10. Maki Y, Yamaguchi T, Yamagami T, Murai T, Hachisuka K, Miyamae F, et al. The impact of subjective memory complaints on quality of life in community-dwelling older adults. Psychogeriatrics. 2014 Sep; 14(3):175–81. [PubMed: 25142381]
11. Mewton L, Sachdev P, Anderson T, Sunderland M, Andrews G. Demographic, clinical, and lifestyle correlates of subjective memory complaints in the Australian population. Am J Geriatr Psychiatry. 2014 Nov; 22(11):1222–32. [PubMed: 23880335]
12. Bherer L, Erickson KI, Liu-Ambrose T. A review of the effects of physical activity and exercise on cognitive and brain functions in older adults. J Aging Res. 2013; 2013:657508. [PubMed: 24102028]
13. Chodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA, Minson CT, Nigg CR, Salem GJ, et al. American College of Sports Medicine position stand. Exercise and physical activity for older adults. 2009:1510–30. 2009/06/12.
14. Heyn P, Abreu BC, Ottenbacher KJ. The effects of exercise training on elderly persons with cognitive impairment and dementia: a meta-analysis. Arch Phys Med Rehabil. 2004 Oct; 85(10): 1694–704. [PubMed: 15468033]
15. Larson EB, Bruce RA. Health benefits of exercise in an aging society. Arch Intern Med. 1987 Feb; 147(2):353–6. [PubMed: 3545119]

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16. Sawatzky R, Liu-Ambrose T, Miller WC, Marra CA. Physical activity as a mediator of the impact of chronic conditions on quality of life in older adults. 2007:68. 2007/12/21.

17. Spirduso WW, Cronin DL. Exercise dose-response effects on quality of life and independent living in older adults. 2001; 33:S598–S608.

18. Hagovska M, Olekszyova Z. Impact of the combination of cognitive and balance training on gait, fear and risk of falling and quality of life in seniors with mild cognitive impairment. Geriatr Gerontol Int. 2016 Sep; 16(9):1043–50. [PubMed: 26338465]

19. Shah KN, Lin FV, Yu F, McMahon JM. Activity engagement and physical function in old age sample. Arch Gerontol Geriatr. 2017 Mar.69:55–60. [PubMed: 27888736]

20. Blackwood J, Shubert T, Fogarty K, Chase C. The Impact of a Home-Based Computerized Cognitive Training Intervention on Fall Risk Measure Performance in Community Dwelling Older Adults, a Pilot Study. J Nutr Health Aging. 2016 Feb; 20(2):138–45. [PubMed: 26812509]

21. Han JW, Lee H, Hong JW, Kim K, Kim T, Byun HJ, et al. Multimodal Cognitive Enhancement Therapy for Patients with Mild Cognitive Impairment and Mild Dementia: A Multi- Center, Randomized, Controlled, Double-Blind, Crossover Trial. J Alzheimers Dis. 2017; 55(2):787–96. [PubMed: 27802233]

22. Barnes DE, Santos-Modesitt W, Poelke G, Kramer AF, Castro C, Middleton LE, et al. The Mental Activity and eXercise (MAX) Trial: A Randomized, Controlled Trial to Enhance Cognitive Function in Older Adults. Arch Int Med. 2013 In Press.

23. Rickli R, Jones J. Functional fitness normative scores for community-residing older adults, ages 60–94. Journal of Aging and Physical Activity. 1999; 7:161–81.

24. Ware J Jr, Kosinski M, Keller SD. A 12-Item Short-Form Health Survey: construction of scales and preliminary tests of reliability and validity. Medical care. 1996; 34:220–33. [PubMed: 8628042]

25. Stewart AL, Mills KM, King AC, Haskell WL, Gills D, Ritter PL. CHAMPS physical activity questionnaire for older adults: Outcomes for interventions. 2001; 33:1126–41.

26. Teng EL, Chui HC. The Modified Mini-Mental State (3MS) examination. J Clin Psychiatry. 1987 Aug; 48(8):314–8. [PubMed: 3611032]

27. Yesavage JA, Brink TL, Rose TL, Lum O, Huang V, Adey M, et al. Development and validation of a geriatric depression screening scale: a preliminary report. J Psychiatr Res. 1982; 17(1):37–49. [PubMed: 7183759]

28. Fitzpatrick AL, Buchanan CK, Nahin RL, DeKosky ST, Atkinson HH, Carlson MC, et al. Associations of gait speed and other measures of physical function with cognition in a healthy cohort of elderly persons. 2007; 62:1244–51.

29. Potter R, Ellard D, Rees K, Thorogood M. A systematic review of the effects of physical activity on physical functioning, quality of life and depression in older people with dementia. Int J Geriatr Psychiatry. 2011 Oct; 26(10):1000–11. [PubMed: 21905096]

30. Taaffe DR, Irie F, Masaki KH, Abbott RD, Petrovitch H, Ross GW, et al. Physical activity, physical function, and incident dementia in elderly men: the Honolulu-Asia Aging Study. J Gerontol A Biol Sci Med Sci. 2008; 63(5):529–35. [PubMed: 18511759]

31. Wang L, Larson EB, Bowen JD, van Belle G. Performance-based physical function and future dementia in older people. Archives of internal medicine. 2006; 166:1115–20. [PubMed: 16717174]

32. den Ouden ME, Schuurmans MJ, Brand JS, Arts IE, Mueller-Schotte S, van der Schouw YT. Physical functioning is related to both an impaired physical ability and ADL disability: A ten year follow-up study in middle-aged and older persons. Maturitas. 2012 Nov 15.

33. Kempen GI, Ormel J. The impact of physical performance and cognitive status on subsequent ADL disability in low-functioning older adults. Int J Geriatr Psychiatry. 1998 Jul; 13(7):480–3. [PubMed: 9695038]

34. Erickson KI, Voss MW, Prakash RS, Basak C, Szabo A, Chaddock L, et al. Exercise training increases size of hippocampus and improves memory. Proc Natl Acad Sci U S A. 2011 Feb 15; 108(7):3017–22. [PubMed: 21282661]

35. Kramer AF, Colcombe SJ, McAuley E, Scalf PE, Erickson KI. Fitness, aging and neurocognitive function. 2005:124–7. 2005/10/11.

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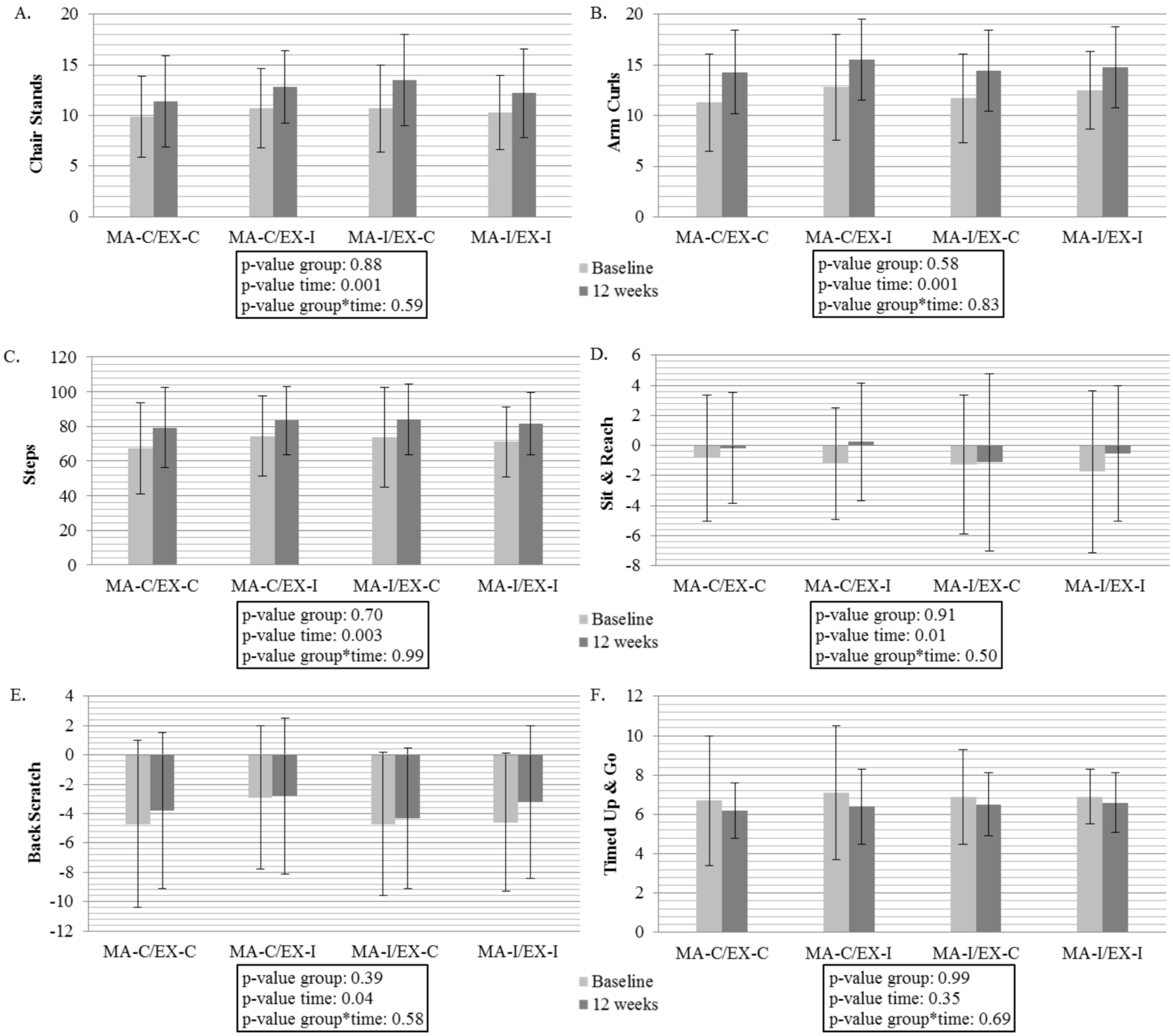
36. Nagamatsu LS, Handy TC, Hsu CL, Voss M, Liu-Ambrose T. Resistance training promotes cognitive and functional brain plasticity in seniors with probable mild cognitive impairment. Arch Intern Med. 2012 Apr 23; 172(8):666–8. [PubMed: 22529236]

37. Wegrzynowska-Teodorczyk K, Mozdzanowska D, Josiak K, Siennicka A, Nowakowska K, Banasiak W, et al. Could the two-minute step test be an alternative to the six-minute walk test for patients with systolic heart failure? Eur J Prev Cardiol. 2016 Aug; 23(12):1307–13. [PubMed: 26743588]

38. Motl RW, McAuley E. Physical activity, disability, and quality of life in older adults. Phys Med Rehabil Clin N Am. 2010 May; 21(2):299–308. [PubMed: 20494278]

39. Carlson MC, Saczynski JS, Rebok GW, Seeman T, Glass TA, McGill S, et al. Exploring the Effects of an "Everyday" Activity Program on Executive Function and Memory in Older Adults: Experience Corps (R). 2008; 48:793–801.

40. Mortimer JA, Ding D, Borenstein AR, DeCarli C, Guo Q, Wu Y, et al. Changes in brain volume and cognition in a randomized trial of exercise and social interaction in a community-based sample of non-demented Chinese elders. J Alzheimers Dis. 2012; 30(4):757–66. [PubMed: 22451320]



Figures 1.

A–F. Performance on measures of physical function at baseline versus 12 week follow-up in all four randomization groups (MA-C/EX-C, MA-C/EX-I, MA-I/EX-C, MA-I/EX-I).

(A) Number of chair stands completed in 30 seconds. (B) Number of arm curls. (C) Number of steps in 120 seconds. (D) Sit and reach in inches. (E) Back scratch in inches. (F) Timed Up & Go in seconds. Higher scores reflect better performance for A-E, while lower scores reflect better performance for F.

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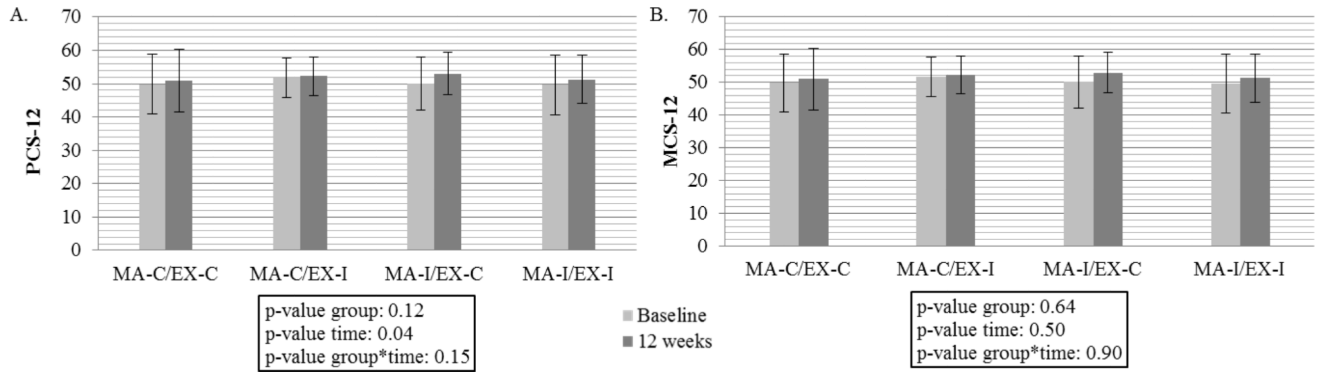

Figures 2.

A–B. Health-related quality of life (HRQOL) at baseline versus 12 week follow-up in all four randomization groups (MA-C/EX-C, MA-C/EX-I, MA-I/EX-C, MA-I/EX-I).

(A) The Short Form-12 physical component sub-score (PCS-12) which reflects physical HRQOL. (B) The Short Form-12 mental component sub-score (MCS-12) which reflects mental HRQOL.

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Table 1

Baseline characteristics by randomization group.

Characteristic	Mental Activity Control		Mental Activity Intervention		p-value
	Exercise Control (n=32)	Exercise Intervention (n=31)	Exercise Control (n=31)	Exercise Intervention (n=32)	
Age, years	73.9 (6.3)	71.1 (5.5)	73.8 (5.7)	74.8 (6.1)	0.08
Gender, female	20 (62.5)	21 (67.7)	18 (58.1)	20 (62.5)	0.89
Education, years	16.3 (2.1)	15.6 (2.8)	16.8 (2.3)	16.7 (2.2)	0.18
Race/ethnicity, non-Hispanic white	22 (68.8)	17 (54.8)	22 (71.0)	21 (65.6)	0.55
Global cognition (3MS)	94.8 (4.7)	94.6 (5.6)	94.4 (3.9)	94.0 (5.2)	0.92
Hypertension	17 (53.1)	20 (64.5)	14 (45.2)	19 (59.4)	0.45
Diabetes	5 (15.6)	5 (16.1)	4 (12.9)	3 (9.4)	0.85
Myocardial infarction	4 (12.5)	2 (6.5)	3 (9.7)	2 (6.3)	0.79
Current/former smoker	16 (53.3)	18 (58.1)	12 (40.0)	16 (51.6)	0.54
Physical performance					
Chair stands (/30s)	9.9 (4.1)	10.7 (3.9)	10.7 (4.3)	10.3 (3.7)	0.86
Arm curls (/30s)	11.3 (4.8)	12.8 (5.2)	11.7 (4.4)	12.5 (3.8)	0.56
Step test (/2min)	67 (26)	74 (23)	73 (28)	71 (20)	0.68
Sit & reach (in)	−0.8 (4.2)	−1.2 (3.7)	−1.2 (4.6)	−1.7 (5.4)	0.88
Back scratch (in)	−4.7 (5.7)	−2.9 (4.9)	−4.7 (4.9)	−4.6 (4.7)	0.41
Up & go (s)	6.7 (3.3)	7.1 (3.4)	6.9 (2.4)	6.9 (1.4)	0.97
HRQOL					
Physical	46.3 (9.9)	47.3 (8.3)	49.8 (7.1)	45.1 (8.4)	0.19
Mental	49.8 (8.9)	51.7 (5.9)	50.1 (8.0)	49.6 (8.9)	0.74

* Values reflect mean (standard deviation) or number (percent). P-values based on analysis of variance or Chi-square test across the four groups. Data missing as follows: education (n=3), race/ethnicity (n=1), smoking status (n=4). 3MS, Modified Mini-Mental State Examination. No significant differences between the mental activity intervention (MA-I) and mental activity control (MA-C) groups (ignoring exercise), exercise intervention (EX-I) and exercise control (EX-C) groups (ignoring mental activity), or all four randomization groups (MA-C/EX-C, MA-C/EX-I, MA-I/EX-C, MA-I/EX-I).

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Table 2

Association between change in frequency of leisure activity and change in physical function and HRQOL.

Measure	Spearman's Correlation (r)	P-value
Senior Fitness Test		
Chair stands (/30s)	0.27	0.001
Arm curls (/30s)	0.22	0.006
Step test (/2min)	0.15	0.05
Sit & reach (in)	0.19	0.02
Back scratch (in)	0.12	0.08
Up & go (s)	0.004	0.96
SF-12		
Physical (PCS-12)	0.26	0.002
Mental (MCS-12)	−0.02	0.82