Effects of golf training on cognition in older adults: a randomised controlled trial

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ABSTRACT

Background Although research indicates that a physically active lifestyle has the potential to prevent cognitive decline and dementia, the optimal type of physical activity/exercise remains unclear. The present study aimed to determine the cognitive benefits of a golf-training programme in community-dwelling older adults.

Methods We conducted a randomised controlled trial between August 2016 and June 2017 at a general golf course. Participants included 106 Japanese adults aged 65 and older. Participants were randomly assigned to either a 24-week (90–120 min sessions/week) golf-training group or a health education control group. Postintervention changes in Mini-mental State Examination (MMSE) and National Centre for Geriatrics and Gerontology-Functional Assessment Tool scores were regarded as primary outcome measures. Secondary outcome measures included changes in physical performance and Geriatric Depression Scale (GDS) scores.

Results A total of 100 participants (golf training, n=53; control, n=47) completed the assessments after the 24-week intervention period. The adherence to the golf programme was 96.2% (51/53 participants). Analysis using linear mixed models revealed that the golf training group exhibited significantly greater improvements in immediate logical memory (p=0.033), delayed logical memory (p=0.009) and composite logical memory (p=0.013) scores than the control group. However, no significant changes in MMSE, word memory, Trail Making Test or Symbol Digital Substitution Test scores were observed. In addition, no significant changes in grip strength, walking speed or GDS were observed.

Conclusions Golf-based exercise interventions may improve logical memory in older adults, but no significant changes in other cognitive tests. Further follow-up investigations are required to determine whether the observed effects are associated with delayed onset of mild cognitive impairment or Alzheimer's disease in older adults.

Trial registration number UMIN-CTR UMIN000024797; Pre-results.

INTRODUCTION

Decreases in cognitive function accelerate after age 60, with fluid cognitive processes such as working memory, executive function or processing speed particularly vulnerable to age-related impairment.[1] Epidemiological data suggest that moderate exercise and engaging in cognitive activities are associated with a lower risk of dementia[2] as well as various cognitive benefits.[3 4] However, data from interventional studies have been insufficient to establish whether physical or cognitive activity interventions improve cognition and prevent dementia in older adults.[5 6]

Animal studies suggest that the combination of exercise and environmental enrichment, modification of the physical environment of animals to stimulate the brain, produces greater neural and cognitive benefits than exercise alone.[7] This observation is supported by some studies that have shown that combined cognitive training and physical activity training improves cognitive abilities in older adults more than either intervention alone.[8–10] A systematic review concluded that combined cognitive and exercise training may be effective for improving cognitive function and functional status in older adults, although the paucity of evidence for this approach in older adults exhibiting cognitive impairment was noted.[11] These results suggest that focusing only on exercise or cognitive training when examining the impact of intervention on cognition fails to consider that activities vary considerably in the degree of sensorimotor complexity, cognitive demand and social interaction that they entail.[12]

Golf is a major sport played by 55 million people in 206 countries. Both men and women tend to play throughout life,[13] and golfers more frequently continue to play into old age than participants involved in sports such as football and rugby.[14] In the physical domain, golf demands high levels of hand–eye coordination, postural control, balance and physical stamina.[15] In the cognitive domain, golf demands maintaining information in working memory, strategy planning, attention and visual-related skill. In addition, novices and skilled practitioners have been found to differ in the way in which cognitive operations are used for purposes of visual search, memory, attention and anticipation in a variety of sports including golf.[16 17] In the social domain, golfers must communicate with one another during each game, which can lead to the development of more personal relationships outside of the competitive context.

As golf is a multifaceted activity with physical, cognitive and social demands, golf-based interventions may be effective in attenuating and/or preventing physical and cognitive decline in older adults. A research group at the University of Regensburg, Germany, reported that 20 sessions of golf training improved visual imagery ability in patients with stroke, even in the late phase.[18] However, few studies have examined whether golf-based interventions can increase

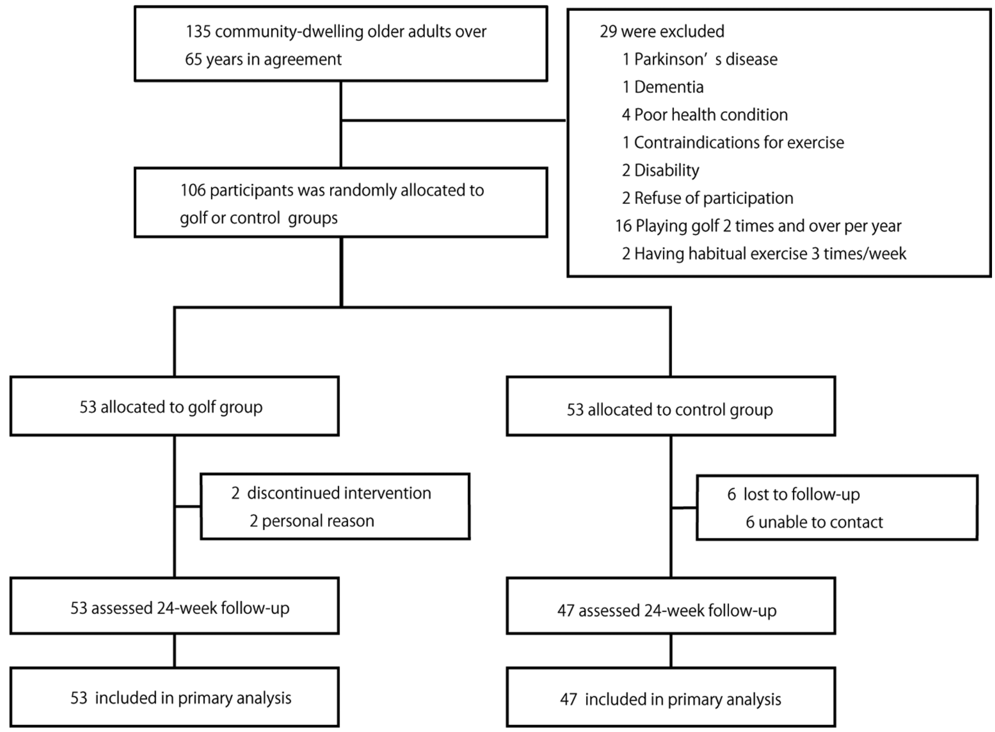

Figure 1 Screening and randomisation.

cognitive and physical performance in healthy older adults. Therefore, we conducted a randomised controlled trial to determine the physical and cognitive benefits of a golf training programme in healthy older adults with little to no experience playing golf (less than two times per year).

METHODS

Study design

We designed a randomised, single-blind controlled trial to compare the cognitive and physiological effects of a golf programme with those of a health education programme (control) in older adults. The trial protocol was approved by the Ethics Committee of the National Centre for Geriatrics and Gerontology, and registered in the University Hospital Medical Information Network Clinical Trials Registry (UMIN000024797). All participants provided written informed consent in accordance with the tenets of the Declaration of Helsinki and were not provided any stipend.

Screening and randomisation

Advertisements were used to recruit participants using publicly available information from five local governments. Figure 1 includes a flow chart depicting each phase of the study. We assessed 135 individuals aged 65 years and older, although we excluded participants with a history of Parkinson's disease (n=1), dementia (n=1), poor health (n=4), contraindications for exercise (n=1) or disability (n=2). Those who refused to participate (n=2), who played golf two or more times per year (n=16) and who engaged in habitual vigorous exercise (three or more times per week) (n=2) were also excluded. A meta-analysis showed that the older adults who performed a habitual vigorous exercise were significantly protected against cognitive decline (HR 0.62, 95% CI 0.54 to 0.70).[19] We concluded that the habitual vigorous exercise could be a bias for this study using exercise as an intervention. The 106 participants in the eligible group (figure 1) were assigned to either the golf training group (n=53) or the health education group (n=53) using a ratio of 1:1. After the baseline assessment, subjects were randomised using the option 'random sample of cases' in SPSS statistics software (V.24; IBM Japan, Tokyo, Japan). A researcher who was not aware of the aims of the study performed the randomisation procedure.

Golf programme

Participants of the golf training group underwent weekly golf sessions (duration: 90–120 min each) focused on physical, cognitive and social activities for a total of 24 weeks. Between 7 and 10 individuals participated in each class at Hidaka Country Club, Hidaka City, Japan. One professional golfer and four to six staff members conducted each intervention session. The golf programme included 14 practice sessions and 10 golf course sessions. Practice sessions began with a 10 min warm-up period and stretching exercises. During sessions 1–9, participants engaged in 70 min of Starting New at Golf (SNAG) training. During sessions 7–14, participants practised at a driving range. All sessions concluded with a 10 min cool-down period. SNAG is the regarded as the optimal programme for effectively teaching the game of golf to individuals of all ages and ability levels. Golf course sessions began with a 10 min warm-up period and stretching exercises, followed by a half-round of golf (100 min) and a 10 min cool-down period.

The aim of the golf programme was to increase cognitive function in the participants. Thus, instructors facilitated cognitive activities such as learning swing form and golf rule and encouraged social interactions between the participants during the golf programme. Participants also performed home-based golf practice each day and were encouraged to continue learning about golf. To improve health behaviour, golf trainers lectured the participants on the methods of golf training and ways to self-monitor their regular physical activity.

Control health education programme

Participants in the control group attended two 90 min health education classes focused on health promotion during the study period. The instructors provided participants with information regarding exercise and healthy diets, although no specific information or recommendations regarding cognitive health were provided. The research staff made additional contact with participants during the study period via telephone to promote adherence to the education programme and retention of information.

Outcomes

The outcome measures were assessed at baseline and at the end of the intervention by study personnel blinded to group assignments. Postintervention changes in general cognitive status and specific cognitive functions were regarded as the primary outcome measures. General cognitive status was assessed using the Mini-Mental State Examination (MMSE),[20] while cognitive functions were assessed using the National Centre for Geriatrics and Gerontology-Functional Assessment Tool (NCGG-FAT).[21] The NCGG-FAT consists of the following domains: memory (immediate and delayed word-list memory and immediate and delayed logical memory), attention (an electronic tablet version of the Trail Making Test-Part A (TMT-part A)), executive function (an electronic tablet version of the Trail Making Test-Part B (TMT-part B)) and processing speed (an electronic tablet version of the Symbol Digit Substitution Test (SDST)). Participants were given approximately 20 min to complete the tablet-based assessments. The NCGG-FAT has been shown to exhibit high test–retest reliability,[21] moderate-to-high criterion-related validity[21] and predictive validity for dementia[22] among community-dwelling older adults.

Secondary outcome measures included changes in physical performance, grip strength, walking speed and depressive symptoms. Maximum hand-grip strength was measured in kilograms using a handheld Smedley-type dynamometer (GRIP-D; Takei, Niigata, Japan). Walking speed was measured in seconds using a stopwatch. Participants were asked to walk on a flat and straight surface at a comfortable walking speed. Two markers were used to indicate the start and end of a 2.4-metre walk path, with a 2-metre section to be traversed prior to passing the start marker so that participants were walking at a comfortable pace by the time they reached the timed path. Participants were asked to continue walking for an additional 2 m past the end of the path to ensure a consistent walking pace while on the timed path.[23] The average of the results for five walking speed trials was used as the representative value for each participant. Depressive symptoms were assessed using the 15-item Geriatric Depression Scale (GDS).[24]

Statistical analysis

All analyses were conducted using SPSS V.24.0. Based on our previous study,[25] we estimated that a total of 90 participants would provide 80% power for detecting a significant between-group difference with regard to changes in the delayed logical memory score, with a moderate effect size of 0.15. We calculated an adherence of the golf programme, which was defined as attending at least 80% of the sessions. Independent samples t-test or χ^2 tests were used to compare baseline characteristics between golf training and education control groups. We analysed the primary and secondary outcomes of a continuous type using a using linear mixed model in order to treat the missing data at the post assessment. All models included random intercepts to account for correlations between the repeated measures for each participant. The fixed components of the models included effects of group and time, which was follow-up time and that was similar in the intervention and control groups, and a group×time interaction. To assess the presence of a group and time effect, where this may change over time, we first determined the existence of time, group and group×time interactions. Age, sex, educational level,[26] history of stroke[27] and regular physical activity[28] were included as covariates of cognitive decline in the multivariable models. All statistical tests were two-sided with an alpha level set at 0.05.

RESULTS

Baseline characteristics and completion rates

The screening, randomisation and follow-up results are summarised in figure 1. There were no significant differences in demographic variables, clinical variables, cognitive/physical function or GDS scores between the golf and control groups at baseline (table 1).

A total of 100 participants (golf group, n=53; control group, n=47) completed the assessments following the 24-week intervention period (figure 1). Two participants randomised to the golf group dropped out of the programme, although they participated in the postintervention assessments. Six participants allocated to the control group did not participate in the postintervention assessments. The adherence to the golf programme was 96.2% (51/53 participants).

Changes in outcome measures

Intra-individual and between-group differences in cognitive and physical outcomes are summarised in table 2. The golf group exhibited significantly greater improvements in immediate logical memory (p=0.033), delayed logical memory (p=0.009) and composite logical memory (p=0.013) than controls (figure 2). However, no significant changes in MMSE, word memory, TMT or SDST scores were observed. We also observed no significant differences in secondary outcome measures such as grip strength, walking speed or GDS scores between the groups (table 2). We confirmed similar results in the unadjusted model. The unadjusted model revealed that the golf group indicated significant improvements in immediate logical memory, delayed logical memory and composite logical memory compared with controls ($p<0.05$), but there were no significant differences in other variables.

Safety

There were no severe adverse events adjudicated to be related to the interventions in either group during the study period.

DISCUSSION

The findings of the present study indicated that the 24-week golf-based exercise intervention significantly improved logical memory function in older adults. However, no significant changes in MMSE, word memory, Trail Making Test or Symbol Digital Substitution Test scores were observed. In addition, no significant changes in grip strength, walking speed or GDS were observed.

In the logical memory tests, these positive findings are consistent with the results of our preliminary exercise intervention clinical trial involving patients with mild cognitive impairment (MCI).[25 29] The results of these previous studies suggest that a composite approach involving exercises designed to increase muscle strength, aerobic exercise with additional cognitive demands, and education aimed at improving health behaviours

Table 1 Baseline characteristics of the study participants

Characteristic	Golf (n=53)	Control (n=53)	P values
Age, mean±SD, years	70.1±4.0	70.7±4.7	0.474
Men, n (%)	28 (52.8)	29 (54.7)	0.846
Educational level, mean±SD, years	12.8±2.8	13.7±2.6	0.089
Diagnosis, n (%)			
Stroke	5 (9.4)	1 (1.9)	0.093
Mild to moderate habitual exercise, n (%)	26 (49.1)	26 (49.1)	1.000
Cognitive functions, mean±SD			
Mini-mental State Examination, score	28.4±1.8	28.7±1.4	0.398
NCGG-FAT			
Immediate word memory, score	8.1±1.3	8.2±1.3	0.706
Delayed word memory, score	8.0±1.4	8.3±1.8	0.363
Composite word memory, score	16.1±2.4	16.4±2.8	0.458
Immediate logical memory, score	7.5±1.7	7.7±1.8	0.475
Delayed logical memory, score	7.3±1.8	7.6±1.5	0.362
Composite logical memory, score	14.8±3.5	15.3±3.2	0.404
Trail Making Test (Part A), s	21.1±5.9	20.3±5.9	0.491
Trail Making Test (Part B) s	36.4±15.3	37.8±17.8	0.666
Symbol Digit Substitution Test, score	45.3±10.4	47.7±10.2	0.234
Physical functions, mean±SD			
Grip strength, kg	28.7±9.8	28.0±8.3	0.682
Walking speed, m/s	1.3±0.2	1.3±0.2	0.772
Psychological tests, mean±SD			
Geriatric Depression Scale, score (4*)	2.5±2.4	2.5±2.0	0.964

Independent samples t-test or χ^2 tests were used to compare baseline characteristics.
*Number of missing values.
NCGG-FAT, National Centre for Geriatrics and Gerontology-Functional Assessment Tool.

exerts beneficial effects on cognitive and motor function in older adults with MCI, possibly to a greater extent than exercise alone.[8–10] Further investigation is required to identify why word-list memory, attention, executive function, processing speed and global cognitive function did not improve for the golf-based interventions.

One potential reason for these negative results may be due to insufficient amount of physical activity during the programme. In fact, there were no effects of golf on physical performance as well as cognitive functions during the 6-month intervention period, although previous studies of golf have indicated that golf may improve proprioception, balance, muscular endurance and muscular performance, particularly in older adults.[30–32] Based on Metabolic Equivalent of Task (MET) values, researchers have generally agreed that golf is a moderate-intensity aerobic activity, with a mean estimated MET value of 4.5.[33] Thus, golf may exert

Table 2 Comparison of cognitive and physical functions between golf and control groups

	Mean difference (95% CI) between baseline and postintervention values		Time	Group	Group×time
	Golf (n=53)	Control (n=53)	P values	P values	P values
MMSE, score	0.19 (−0.28 to 0.66)	−0.31 (−0.8 to 0.18)	0.723	0.962	0.149
Immediate word memory, score	0.26 (−0.01 to 0.54)	0.22 (−0.07 to 0.52)	0.019	0.725	0.839
Delayed word memory, score	0.15 (−0.37 to 0.67)	0.17 (−0.36 to 0.71)	0.387	0.206	0.950
Composite word memory, score	0.42 (−0.27 to 1.1)	0.41 (−0.31 to 1.12)	0.103	0.364	0.983
Immediate logical memory, score	0.74 (0.23 to 1.24)	−0.06 (−0.58 to 0.47)	0.066	0.577	0.033
Delayed logical memory, score	0.93 (0.45 to 1.4)	0 (−0.5 to 0.5)	0.009	0.566	0.009
Composite logical memory, score	1.66 (0.73 to 2.59)	−0.06 (−1.03 to 0.92)	0.021	0.561	0.013
Trail Making Test (Part A), s	0.64 (− 1.54 to 2.83)	1.65 (−0.63 to 3.93)	0.153	0.809	0.528
Trail Making Test (Part B), s	0.42 (−2.85 to 3.68)	−0.45 (−3.89 to 2.99)	0.989	0.758	0.719
Digit symbol Substitution Test, score	2.6 (0.62 to 4.59)	1.23 (−0.87 to 3.32)	0.010	0.37	0.346
Grip strength, kg	0.85 (0.04 to 1.67)	1.26 (0.40 to 2.13)	0.001	0.763	0.494
Walking speed, m/s	−0.01 (−0.06 to 0.04)	0.05 (0 to 0.10)	0.26	0.555	0.073
GDS, score	−0.67 (−1.14 to −0.20)	−0.37 (−0.86 to 0.11)	0.003	0.792	0.389

GDS, Geriatric Depression Scale; MMSE, Mini-Mental State Examination.

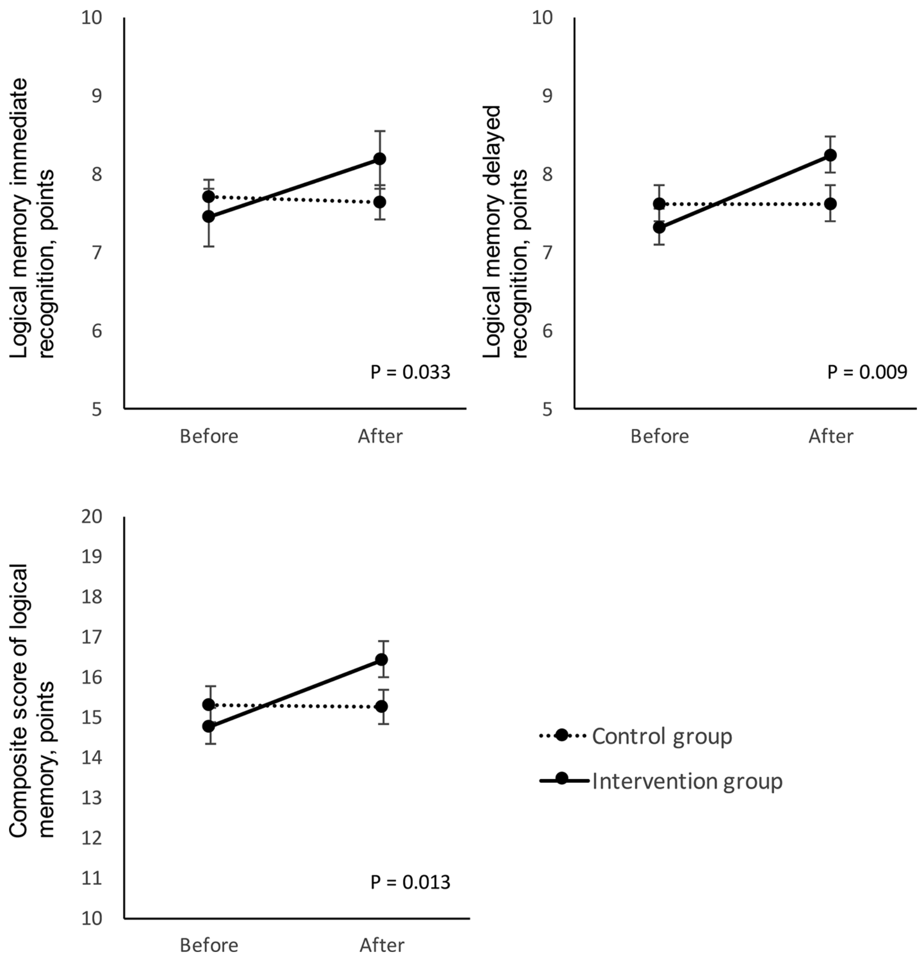

Figure 2 Changes in logical memory score. The p value was calculated from an analysis of between-group differences adjusted for age, sex, educational level, history of stroke and regular physical activity.

beneficial effects in the prevention and treatment of chronic diseases, as physical inactivity is known to increase the risk of many adverse health conditions, including major non-communicable diseases such as coronary heart disease, type 2 diabetes, and breast and colon cancers.[34] We considered that it was necessary to increase the amount of physical activity during the golf programme to improve cognitive and physical performances in the older adults.

Several studies have demonstrated that cognitive retraining and social activities improve cognitive function in older adults. A systematic review revealed that computerised cognitive training improved non-verbal memory, verbal memory, working memory, processing speed and visuospatial skills in older adults, with small to moderate effect sizes.[35] In addition, a randomised controlled trial reported that a time-extended 6-year program was associated with significantly greater improvements in memory than an 11-week intensive programme, and that the effects of the latter tended to decay over time.[36] These results suggest that cognitive training can improve memory function, and that continued training is required to maintain these improvements. Golf is particularly advantageous in this regard when compared with other forms of exercise or sports due to the elements of the game and social interaction required. Since older adults gain more leisure time through retirement or reduced working hours, choosing a leisure activity that is physically based may allow such individuals to fulfil their physical and psychological needs.[37] Previous studies have indicated that individuals engage in sports-based leisure activities for various reasons other than health: to give life purpose, to escape from problems, to have fun and to engage socially. The game-like atmosphere of the sport is integral in developing social networks,[38] which has been shown to help individuals cope with life[39] and influence overall health.[40] The level of concentration (or competition) required to improve skills or meet personal goals is a key factor influencing participation in sports.[41] The perseverance and competition required of many sports-based activities offer participants the opportunity for engagement and accomplishment as well as physical involvement. These social and psychological aspects of golf may facilitate continuous physical activity and promote cognitive health in older adults.

The present study possesses several limitations of note. As we included only a small sample of older adults, our findings should be replicated in a larger population. No significant differences in physical function, GDS scores or cognitive functions other than memory were observed between the groups. As the short duration of the intervention period and limited number of physical function tests may have influenced the results, further long-term studies using various tests are required to determine the effects of golf training on cognitive function and physical performance in older adults. Among the 135 individuals screened for eligibility, 29 were excluded for not meeting inclusion criteria, refusal to participate or medical reasons (figure 1). This selection bias may have affected the generalisability of our findings to population-based samples. Other limitations include unknown group differences in risk factors for cognitive decline, such as physical activity level and apolipoprotein E ε4 genotype.[42] However, there were no significant differences between groups in terms of education, chronic diseases, cognitive function, physical performance or depressive mood at baseline.

Despite these limitations, our findings suggest that golf-based interventions can improve logical memory function in older adults. Furthermore, our results demonstrated that older adults can start playing golf at any age, and that the persistence rate is very high among those who begin such programmes. There are 2383 golf courses in Japan, and many staff members are available as social resources. Therefore, golf-based intervention programmes may be relatively easy to implement. We formed a consortium with the Professional Golf Association and the Golf Course Association, and are currently preparing for social implementation of the golf programme at the level of health policy.

In summary, the results of the present single-blind controlled trial demonstrated that a 24-week golf programme was effective in improving logical memory function in older adults. Moreover, our findings indicated that adherence to the golf programme was high in older adults, even among those with no golf experience. Further follow-up investigations are required to determine whether the observed effects are associated with prevention or delayed onset of MCI or Alzheimer's disease in older adults.

What is already known on this subject

- Golf may exert beneficial effects in the prevention and treatment of chronic diseases, including major non-communicable diseases such as coronary heart disease, type 2 diabetes, and breast and colon cancers.
- However, few studies have examined whether golf-based interventions can increase cognitive performance in healthy older adults.

What this study adds

- Our findings indicated that adherence to the golf programme was high in older adults, even among those with no golf experience.
- Golf-based interventions may be effective in improving logical memory function in older adults.

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Contributors HS had full access to all data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. HS planned the study, wrote the first draft of the manuscript, and coordinated the review and editing process leading to the final manuscript. SL, MA, KK, KI and KT participated in the design of the study and writing of the manuscript. KN and SI contributed to the editorial process and management of data collection. MT, HK and TT contributed to the editorial process and data collection. KT supervised the study and suggested many of the ideas that have been pursued in this research, and participated in the planning, editorial and review processes that led to the final manuscript.

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Patient consent Obtained.

Ethics approval Ethics Committee of the National Center for Geriatrics and Gerontology.

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