Yoga-plus exercise mix promotes cognitive, affective, and physical functions in elderly people

Abstract

Objectives: Increased attention is being paid to Asian medicine in balanced total health care. We investigated the effects of mixed exercise including yoga ("Yoga-plus") among elderly individuals.

Methods: A total of 385 subjects (75 male and 313 female, 75.5 ± 8.7 years old) participated in a 12-month (M) exercise program at a health and welfare center, a day service center, and a nursing home. Cognitive, affective, and physical functions, and activities of daily living (ADL), were compared at baseline (0M), 6M and 12M of exercise intervention.

Results: Mean scores on the frontal assessment battery, clock drawing test, cube copying test, letter fluency, and category fluency significantly improved after the Yoga-plus intervention, while mini-mental state examination, Hasegawa dementia score-revised, and trail making test performance were relatively stable. Affective scores on the geriatric depression scale (GDS), apathy scale (AS) and Abe's behavioral and psychological symptoms of dementia were not significantly affected by exercise therapy, but subgroups with higher baseline GDS (GDS ≥ 5) and AS (AS ≥ 16) scores showed a significant improvement after intervention. One-leg standing time and 3-m timed up and go test performance significantly improved after 12M intervention.

Discussion: Yoga-plus improved cognitive, affective, ADL, and physical functions in a local elderly population, particularly among below-baseline individuals, indicating the benefits of dementia prevention among elderly individuals.

Keywords: affective function, cognitive function, elderly population, physical function, yoga exercise

Introduction

The proportion of elderly people in the population is rapidly increasing, particularly in Asian countries [1]. As this trend continues, societies will age further, with fewer children, population decline, and an increased number of people with dementia [2]. Japan has the most rapidly aging society, and the Japanese government enacted the "Asia Health and Human Well-Being Initiative" to support the establishment of a system to respond to Asia's rapidly aging population [3]. This policy incorporates Asian traditional medicine, including Chinese herbal medicine, Ayurveda, yoga, and oriental medicine, for the realization of balanced total health care.

A recent study reported that appropriate physical exercise, including aerobic exercise, improved both physical and cognitive functioning among normal subjects, and increased the size of the anterior hippocampus associated with greater serum levels of brain derived neurotrophic factor (BDNF) [4]. Yoga is widely used for physical, mental, and spiritual well-being, and is reported to significantly improve executive function, working memory, attention, and processing speed for healthy participants and individuals with mild cognitive impairment (MCI) and dementia [5-7], as well as improving mental health among elderly people with dementia and MCI [5, 8-11]. Acupressure and massage therapy are also reported to help affective functioning among dementia patients experiencing anxiety, depression, agitation, and sleep problems [12, 13].

In the present study, we developed an original mixed exercise program including yoga, dry massage, aerobics, and pressure point stimulation ("Yoga-plus"), designed for elderly beginners as a part of a care prevention service of the municipality government. We examined the effectiveness of Yoga-plus for cognitive, affective, activities of daily living (ADL), and physical functioning in a local elderly population.

Methods

Participants

In the present prospective clinical study, 385 subjects participated in a 12-month (M) exercise program at three local centers between April 2016 and March 2017 (75 male and 313 female, 75.5 ± 8.7 years old, mean ± SD): a health and welfare center for local community operated by the city government of Okayama prefecture (284 subjects, 40 male and 244 female, 73.8 ± 8.1 years old), a day service center of our affiliated hospital (89 subjects, 25 male and 64 female, 80.0 ± 8.7 years old), and a nursing home at our affiliated hospital (12 subjects, seven male and five female, 80.0 ± 5.4 years old). All participants underwent cognitive and physical function tests, and completed a medical questionnaire regarding affective and ADL functioning at baseline (0M), and at 6M and 12M of exercise intervention. Subjects with past or present central nervous system diseases, psychiatric disorders, or medical treatment for dementia were excluded.

All participants gave written informed consent, and the study protocol was approved by the Ethics Committee of the Okayama University Graduate School of Medicine, Dentistry, and Pharmaceutical Sciences (approval number R1605-001).

Exercise intervention

The exercise intervention was a 15 min program consisting of yoga (e.g., body posing and breathing), dry massage (whole body, particularly head and ears), aerobic exercise, and stimulation of pressure points, specifically designed for elderly beginners. This 15-min program was recorded on DVD and played on local cable television three times per day. The 284 participants at the health and welfare center exercised at least once a week together with instructors, watching the same television program at home on the other days. The 89 participants at the day service center added this exercise to their program at the day service center at least twice a week with instructors, engaging in the same program at home on the other days via DVD. The 12 participants at the nursing home exercised with instructors daily at the nursing home.

Evaluation of cognitive, affective, ADL, and physical functions

Participants were evaluated using cognitive functional tests, including the mini-mental state examination (MMSE), Hasegawa dementia score-revised (HDS-R), frontal assessment battery (FAB), 1 min word recall screening tests (letter and category fluency), clock drawing test (CDT), cube copying test (CCT), trail making test (TMT), and Montreal cognitive assessment (MoCA). In each 1 min word recall screening test, the number of words was counted. CDT and CCT were scored using Rouleau's scoring method [14] and Shimada's scoring method [15], respectively. Depression, apathy, and behavioral and psychological symptoms of dementia (BPSD) were evaluated using the geriatric depression scale (GDS), apathy scale (AS), and Abe's BPSD score (ABS) [16], respectively. ADL was assessed using the Alzheimer's disease cooperative study-activities of daily living (ADCS-ADL) scale. Participants were assessed for grip strength, functional reach test (FRT), one-leg standing, 5-m walking, and 3-m timed up and go test (3mTUG). Some of the tests were carried out only at the day service center and nursing home (MMSE, HDS-R, FAB, ADCS-ADL, FRT, and 5-m walking test).

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp., Armonk, NY, USA). Changes in cognitive, affective, ADL, and physical function assessment scores were analyzed using one-way factorial analysis of variance (ANOVA) among three time points (baseline, 6, and 12 months after exercise therapy intervention). *P*-values below 0.05 were considered significant.

Results

Table 1 summarizes clinical scores for cognitive, affective, and ADL measures, and physical function test results. The number of subjects for the three examinations ranged from 48 to 359 for each item (Table 1). Mean MMSE, HDS-R, and TMT scores were relatively stable at 6 and 12M, even after exercise: MMSE (0M: 21.7 ± 3.9. 6M: 22.5 ± 4.2, 12M: 23.0 ± 4.2), HDS-R (21.7 ± 4.9, 21.8 ± 4.8, and 23.0 ± 4.2, respectively), and TMT (0.5 ± 0.5, 0.5 ± 0.5, and 0.5 ± 0.5, respectively). In contrast, exercise therapy significantly improved FAB scores (0M: 10.7 ± 3.4, 6M: 12.0 ± 3.6, 12M: 13.3 ± 3.6, 0M vs 12M, **$p < 0.01$, and 6M vs 12M, *$p < 0.05$), CDT (0M: 8.6 ± 1.6, 6M: 9.1 ± 1.3, 12M: 9.7 ± 0.7, 0M vs 6M and 12M, **$p < 0.01$, and 6M vs 12M, *$p < 0.05$), CCT (0M: 6.0 ± 1.7, 6M: 6.4 ± 1.2, 12M: 6.7 ± 0.8, 0M vs 6M, *$p < 0.05$, and 0M vs 12M, **$p < 0.01$), letter fluency (0M: 7.8 ± 3.0, 6M: 8.1 ± 3.2, 12M: 8.5 ± 3.6, 0M vs 12M, **$p < 0.01$), and category fluency (0M: 10.1 ± 3.5, 6M: 10.5 ± 3.5, 12M: 11.5 ± 3.7, 0M and 6M vs 12M, **$p < 0.01$).

We performed subanalysis of MMSE, dividing participants into two subgroups according to baseline MMSE scores (≤ 23 and ≥ 24). The low MMSE group (≤ 23) constituted 46.3% (n = 31) of the sample, and the high MMSE group (≥ 24) constituted 53.7% (n = 36) of the sample (Fig. 1A, left). MMSE scores improved non-significantly in the low-baseline MMSE group (Fig. 1A, right). We performed subanalyses of HDS-R, CDT, CCT, and TMT, dividing participants into two subgroups according to the baseline score for each measure: HDS-R (≤ 20 and ≥ 21, Fig. 1B), CDT (≤ 7 and ≥ 8, Fig. 2A), CCT (≤ 5 and ≥ 6, Fig. 2B), and TMT (0 and 1, Fig. 2C). The HDS-R low group (≤ 20) was 20.9% (n = 14), and high group (≥ 21) was 79.1% (n = 53) (Fig. 1B, left). Scores were stable during 12 months in the high-baseline group, while the low-baseline HDS-R (≤ 20) group showed significant improvement after 12M of exercise intervention (*$p < 0.05$) (Fig. 1B, right). Subanalyses of CDT, CCT, and TMT revealed that exercise therapy significantly improved scores of low CDT (0M: 6.4 ± 1.0, 6M: 8.3 ± 1.3, 12M: 9.1 ± 1.1), low CCT (0M: 3.3 ± 1.4, 6M: 5.3 ± 1.4, 12M: 6.1 ± 1.0), and low TMT (0M: 0.0 ± 0.0, 6M: 0.4 ± 0.5, 12M: 0.7 ± 0.5, 0M vs 6M and 12M, *$p < 0.05$, respectively) participants (Fig. 2A–C, right).

Affective scores for total GDS, AS and ABS were not significantly affected by exercise therapy (Table 1). Mean baseline GDS was normal (3.2 ± 3.0), and 65.4% of participants were normal (GDS:

0–4 points), 29.5% exhibited a depressive state (GDS: 5–9 points), and 5.1% were depressed (GDS: ≥ 10 points) (Fig. 3A, left). Subanalysis of the higher-baseline GDS group (GDS ≥ 5) showed significant improvement at 12M exercise intervention (0M: 7.9 ± 2.5 vs 12M: 4.8 ± 3.6, $^{**}p < 0.01$) (Fig. 3A, right). Similarly in AS, 29.4% of high-baseline AS participants (AS ≥ 16) showed significant improvement at 6 and 12M exercise intervention (0M: 21.3 ± 6.0 vs 6M: 16.7 ± 6.8 and 12M: 15.6 ± 7.1, $^{**}p < 0.01$, respectively) (Fig. 3B). ADCS-ADL scores barely changed during 12 M (0M: 21.9 ± 3.6, 6M: 22.9 ± 2.9, 12M: 22.2 ± 6.2) (Table 1).

Physical tests showed no change over 12M in grasping power of both hands, FRT, and 5-m walking tests (Table 1). However, one-leg standing time significantly increased after 12M exercise intervention (0M: 28.1 ± 23.6 and 6M: 33.6 ± 23.7 vs 12M: 36.2 ± 23.2, $^{**}p < 0.01$, respectively). 3-m TUG significantly improved after 12M (0M: 8.8 ± 5.1 and 6M: 7.9 ± 4.1 vs 12M: 6.9 ± 2.8, $^{**}p < 0.01$, respectively).

Discussion

The results revealed that Yoga-plus was effective for maintaining or partially improving cognitive, affective, ADL, and physical functions for a 12M period in an elderly population. Baseline cognitive function (0 M) was relatively low (MMSE 21.7, Table 1), and 46.3% of participants had suspected cognitive decline in MMSE (≤ 23) (Fig. 1 A). After intervention, cognitive scores improved at 6M and 12M in FAB, letter and category fluency, CDT, and CCT (Table 1).

Previous studies reported that yoga and aerobic exercise interventions improved executive function, immediate and delayed recall of verbal, visuospatial memory, attention, working memory, verbal fluency, and processing speed in healthy elderly individuals, MCI and dementia patients [5, 6, 17-20]. The present study confirmed these previous findings (Table 1), particularly among participants with baseline cognitive decline in HDS-R (≤ 20), CDT (≤ 7), CCT (≤ 5), and TMT (= 0) (Fig. 1B, Fig. 2). Yoga and exercise intervention increased hippocampal and medial temporal lobe volumes in magnetic resonance imaging and single-photon emission computed tomography in association with serum increases of BDNF, insulin-like growth factor-1 and vascular endothelial growth factor levels [4, 18, 21-23], and enhanced activation in the prefrontal and parietal cortices [23, 24].

In terms of affective functioning, previous studies reported that exercise and yoga were effective for improving BPSD among dementia patients, including depression, agitation, apathy, night-time sleep [5, 7, 9-11, 24]. Our findings confirmed that Yoga-plus induced time-dependent improvement, particularly in the low-baseline depressive/depression (34.6%) and apathetic (29.4%) groups (Fig. 3A, B). These findings may be related to exercise-induced increases in neurotransmitter concentration and synthesis of neurotrophins such as serotonin, dopamine, epinephrine, norepinephrine, and BDNF [4, 11, 22].

The results revealed a beneficial effect of Yoga-plus on ADL and physical functioning (Table 1), particularly one-leg standing time and 3-m TUG performance, indicating improvements in muscle strength of the lower limbs, dynamic and static balance, walking ability, and agility. Slow walking speed is reported to be an important risk factor for dementia [25], and lower limb function in elderly people is related to cognitive function [26]. Our findings revealed that an exercise intervention improved not only physical functioning, particularly in the lower limbs, but also cognitive functioning (Table 1, bottom).

Overall, a regular 15-min exercise intervention consisting of yoga, dry massage, aerobic exercise, and pressure point stimulation, improved cognitive, affective, ADL, and physical functions in an elderly population. This intervention was particularly effective among participants exhibiting cognitive decline, depressive symptoms, and/or apathy, and helped maintain functioning in healthy individuals. Our previous population-based study revealed that individuals with mild and moderate cognitive decline were more depressive, and performed less habitual exercise [27]. Regular exercise interventions could be useful for preventing cognitive, affective, ADL, and physical functional decline among elderly individuals.

Acknowledgments

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Figure legends

Figure 1. Subjects were divided into two groups according to the baseline cognitive scores (0M) (mini-mental state examination [MMSE] (A, left) and Hasegawa dementia score-revised [HDS-R] (B, left); suspected to be in cognitive decline (MMSE ≤ 23, and HDS-R ≤ 20) and normal (MMSE ≥ 24, and HDS-R ≥ 21). Changes of MMSE (A, right) and HDS-R (B, right) scores show the time-dependent improvements especially in the baseline cognitive-decline groups after 12M exercise intervention (*p < 0.05 significant in HDS-R ≤ 20 vs 0M).

Figure 2. Left side shows baseline (0M) cognitive functional scores for clock drawing test (CDT), cube copying test (CCT), and trail making test (TMT), indicating apparent cognitive decline (CDT = 0–4, CCT0-2, and TMT = 0), slight cognitive decline (CDT = 5–7, CCT = 3–5), and normal range (8 ≤ CDT, 6 ≤ CCT, and TMT = 1) (A–C). Right side shows the significant time-dependent improvements of CDT, CCT, and TMT after exercise intervention (A–C) in the baseline cognitive-decline groups (CDT = 0–7, CCT0-5, and TMT = 0) after 12M (*p < 0.05 vs 0M).

Figure 3. Left side shows baseline prevalence of affective dysfunction of baseline (0M) on the geriatric depression scale (GDS, left panel of A) and apathy scale (AS, left panel of B) in participants divided into subgroups according to the scores, consisted of 29.5% depressive (GDS = 5–9) and 5.1% depression (GDS ≥ 10), and 29.4% apathy (AS ≥ 16). The middle panels show the changes of normal affective scores at baseline, GDS (A) and AS (B), and the right panels show the changes in the depressive/depression group (A), and the apathy group (B) participants. Note the significant improvement of GDS and AS scores in each affective decline group (GDS ≥ 5 and AS ≥ 16) after 12M exercise intervention (**p < 0.01, vs 0M).

Yoga-plus exercise mix promotes cognitive, affective, and physical functions in elderly people

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Running title: Exercise improves physical and mental health in elderly people

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Disclosure of potential conflicts of interest: None.

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Results

Table 1 summarizes clinical scores for cognitive, affective, and ADL measures, and physical function test results. The number of subjects for the three examinations ranged from 48 to 359 for each item (Table 1). Mean MMSE, HDS-R, and TMT scores were relatively stable at 6 and 12M, even after exercise: MMSE (0M: 21.7 ± 3.9. 6M: 22.5 ± 4.2, 12M: 23.0 ± 4.2), HDS-R (21.7 ± 4.9, 21.8 ± 4.8, and 23.0 ± 4.2, respectively), and TMT (0.5 ± 0.5, 0.5 ± 0.5, and 0.5 ± 0.5, respectively). In contrast, exercise therapy significantly improved FAB scores (0M: 10.7 ± 3.4, 6M: 12.0 ± 3.6, 12M: 13.3 ± 3.6, 0M vs 12M, $^{**}p < 0.01$, and 6M vs 12M, $^{*}p < 0.05$), CDT (0M: 8.6 ± 1.6, 6M: 9.1 ± 1.3, 12M: 9.7 ± 0.7, 0M vs 6M and 12M, $^{**}p < 0.01$, and 6M vs 12M, $^{*}p < 0.05$), CCT (0M: 6.0 ± 1.7, 6M: 6.4 ± 1.2, 12M: 6.7 ± 0.8, 0M vs 6M, $^{*}p < 0.05$, and 0M vs 12M, $^{**}p < 0.01$), letter fluency (0M: 7.8 ± 3.0, 6M: 8.1 ± 3.2, 12M: 8.5 ± 3.6, 0M vs 12M, $^{**}p < 0.01$), and category fluency (0M: 10.1 ± 3.5, 6M: 10.5 ± 3.5, 12M: 11.5 ± 3.7, 0M and 6M vs 12M, $^{**}p < 0.01$).

We performed subanalysis of MMSE, dividing participants into two subgroups according to baseline MMSE scores (≤ 23 and ≥ 24). The low MMSE group (≤ 23) constituted 46.3% (n = 31) of the sample, and the high MMSE group (≥ 24) constituted 53.7% (n = 36) of the sample (Fig. 1A, left). MMSE scores improved non-significantly in the low-baseline MMSE group (Fig. 1A, right). We performed subanalyses of HDS-R, CDT, CCT, and TMT, dividing participants into two subgroups according to the baseline score for each measure: HDS-R (≤ 20 and ≥ 21, Fig. 1B), CDT (≤ 7 and ≥ 8, Fig. 2A), CCT (≤ 5 and ≥ 6, Fig. 2B), and TMT (0 and 1, Fig. 2C). The HDS-R low group (≤ 20) was 20.9% (n = 14), and high group (≥ 21) was 79.1% (n = 53) (Fig. 1B, left). Scores were stable during 12 months in the high-baseline group, while the low-baseline HDS-R (≤ 20) group showed significant improvement after 12M of exercise intervention ($^{*}p < 0.05$) (Fig. 1B, right). Subanalyses of CDT, CCT, and TMT revealed that exercise therapy significantly improved scores of low CDT (0M: 6.4 ± 1.0, 6M: 8.3 ± 1.3, 12M: 9.1 ± 1.1), low CCT (0M: 3.3 ± 1.4, 6M: 5.3 ± 1.4, 12M: 6.1 ± 1.0), and low TMT (0M: 0.0 ± 0.0, 6M: 0.4 ± 0.5, 12M: 0.7 ± 0.5, 0M vs 6M and 12M, $^{*}p < 0.05$, respectively) participants (Fig. 2A–C, right).

Affective scores for total GDS, AS and ABS were not significantly affected by exercise therapy (Table 1). Mean baseline GDS was normal (3.2 ± 3.0), and 65.4% of participants were normal (GDS:

0–4 points), 29.5% exhibited a depressive state (GDS: 5–9 points), and 5.1% were depressed (GDS: ≥ 10 points) (Fig. 3A, left). Subanalysis of the higher-baseline GDS group (GDS ≥ 5) showed significant improvement at 12M exercise intervention (0M: 7.9 ± 2.5 vs 12M: 4.8 ± 3.6, **p < 0.01) (Fig. 3A, right). Similarly in AS, 29.4% of high-baseline AS participants (AS ≥ 16) showed significant improvement at 6 and 12M exercise intervention (0M: 21.3 ± 6.0 vs 6M: 16.7 ± 6.8 and 12M: 15.6 ± 7.1, **p < 0.01, respectively) (Fig. 3B). ADCS-ADL scores barely changed during 12 M (0M: 21.9 ± 3.6, 6M: 22.9 ± 2.9, 12M: 22.2 ± 6.2) (Table 1).

Physical tests showed no change over 12M in grasping power of both hands, FRT, and 5-m walking tests (Table 1). However, one-leg standing time significantly increased after 12M exercise intervention (0M: 28.1 ± 23.6 and 6M: 33.6 ± 23.7 vs 12M: 36.2 ± 23.2, **p < 0.01, respectively). 3-m TUG significantly improved after 12M (0M: 8.8 ± 5.1 and 6M: 7.9 ± 4.1 vs 12M: 6.9 ± 2.8, **p < 0.01, respectively).

Discussion

The results revealed that Yoga-plus was effective for maintaining or partially improving cognitive, affective, ADL, and physical functions for a 12M period in an elderly population. Baseline cognitive function (0 M) was relatively low (MMSE 21.7, Table 1), and 46.3% of participants had suspected cognitive decline in MMSE (≤ 23) (Fig. 1 A). After intervention, cognitive scores improved at 6M and 12M in FAB, letter and category fluency, CDT, and CCT (Table 1).

Previous studies reported that yoga and aerobic exercise interventions improved executive function, immediate and delayed recall of verbal, visuospatial memory, attention, working memory, verbal fluency, and processing speed in healthy elderly individuals, MCI and dementia patients [5, 6, 17-20]. The present study confirmed these previous findings (Table 1), particularly among participants with baseline cognitive decline in HDS-R (≤ 20), CDT (≤ 7), CCT (≤ 5), and TMT (= 0) (Fig. 1B, Fig. 2). Yoga and exercise intervention increased hippocampal and medial temporal lobe volumes in magnetic resonance imaging and single-photon emission computed tomography in association with serum increases of BDNF, insulin-like growth factor-1 and vascular endothelial growth factor levels [4, 18, 21-23], and enhanced activation in the prefrontal and parietal cortices [23, 24].

In terms of affective functioning, previous studies reported that exercise and yoga were effective for improving BPSD among dementia patients, including depression, agitation, apathy, night-time sleep [5, 7, 9-11, 24]. Our findings confirmed that Yoga-plus induced time-dependent improvement, particularly in the low-baseline depressive/depression (34.6%) and apathetic (29.4%) groups (Fig. 3A, B). These findings may be related to exercise-induced increases in neurotransmitter concentration and synthesis of neurotrophins such as serotonin, dopamine, epinephrine, norepinephrine, and BDNF [4, 11, 22].

The results revealed a beneficial effect of Yoga-plus on ADL and physical functioning (Table 1), particularly one-leg standing time and 3-m TUG performance, indicating improvements in muscle strength of the lower limbs, dynamic and static balance, walking ability, and agility. Slow walking speed is reported to be an important risk factor for dementia [25], and lower limb function in elderly people is related to cognitive function [26]. Our findings revealed that an exercise intervention improved not only physical functioning, particularly in the lower limbs, but also cognitive functioning (Table 1, bottom).

Overall, a regular 15-min exercise intervention consisting of yoga, dry massage, aerobic exercise, and pressure point stimulation, improved cognitive, affective, ADL, and physical functions in an elderly population. This intervention was particularly effective among participants exhibiting cognitive decline, depressive symptoms, and/or apathy, and helped maintain functioning in healthy individuals. Our previous population-based study revealed that individuals with mild and moderate cognitive decline were more depressive, and performed less habitual exercise [27]. Regular exercise interventions could be useful for preventing cognitive, affective, ADL, and physical functional decline among elderly individuals.

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Figure legends

Figure 1. Subjects were divided into two groups according to the baseline cognitive scores (0M) (mini-mental state examination [MMSE] (A, left) and Hasegawa dementia score-revised [HDS-R] (B, left); suspected to be in cognitive decline (MMSE $\leq$ 23, and HDS-R $\leq$ 20) and normal (MMSE $\geq$ 24, and HDS-R $\geq$ 21). Changes of MMSE (A, right) and HDS-R (B, right) scores show the time-dependent improvements especially in the baseline cognitive-decline groups after 12M exercise intervention (*p < 0.05 significant in HDS-R $\leq$ 20 vs 0M).

Figure 2. Left side shows baseline (0M) cognitive functional scores for clock drawing test (CDT), cube copying test (CCT), and trail making test (TMT), indicating apparent cognitive decline (CDT = 0–4, CCT0-2, and TMT = 0), slight cognitive decline (CDT = 5–7, CCT = 3–5), and normal range (8 $\leq$ CDT, 6 $\leq$ CCT, and TMT = 1) (A–C). Right side shows the significant time-dependent improvements of CDT, CCT, and TMT after exercise intervention (A–C) in the baseline cognitive-decline groups (CDT = 0–7, CCT0-5, and TMT = 0) after 12M (*p < 0.05 vs 0M).

Figure 3. Left side shows baseline prevalence of affective dysfunction of baseline (0M) on the geriatric depression scale (GDS, left panel of A) and apathy scale (AS, left panel of B) in participants divided into subgroups according to the scores, consisted of 29.5% depressive (GDS = 5–9) and 5.1% depression (GDS $\geq$ 10), and 29.4% apathy (AS $\geq$ 16). The middle panels show the changes of normal affective scores at baseline, GDS (A) and AS (B), and the right panels show the changes in the depressive/depression group (A), and the apathy group (B) participants. Note the significant improvement of GDS and AS scores in each affective decline group (GDS $\geq$ 5 and AS $\geq$ 16) after 12M exercise intervention (**p < 0.01, vs 0M).

Figure1 Click here to access/download;Figure;Figure1.tif

Figure 1

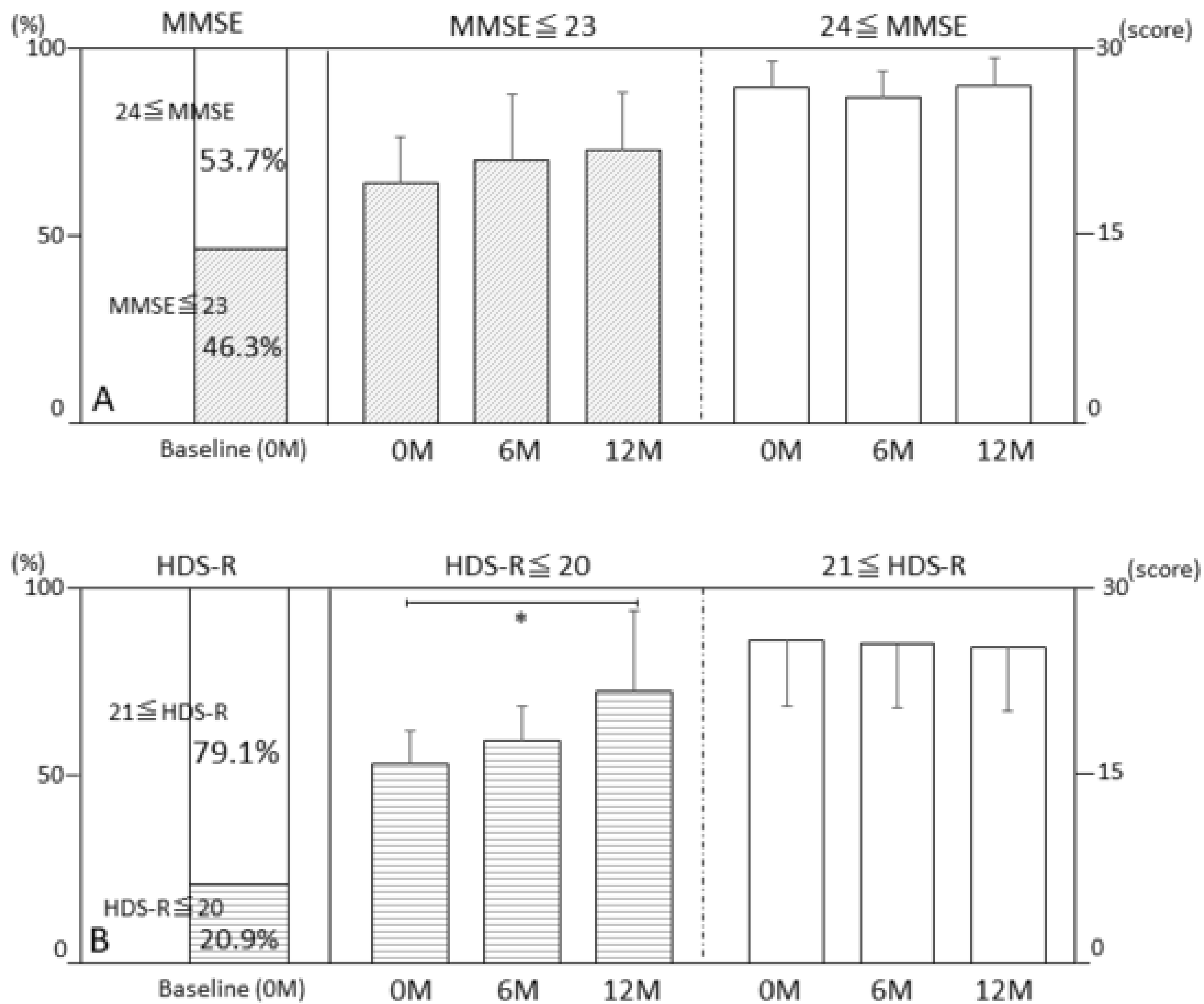
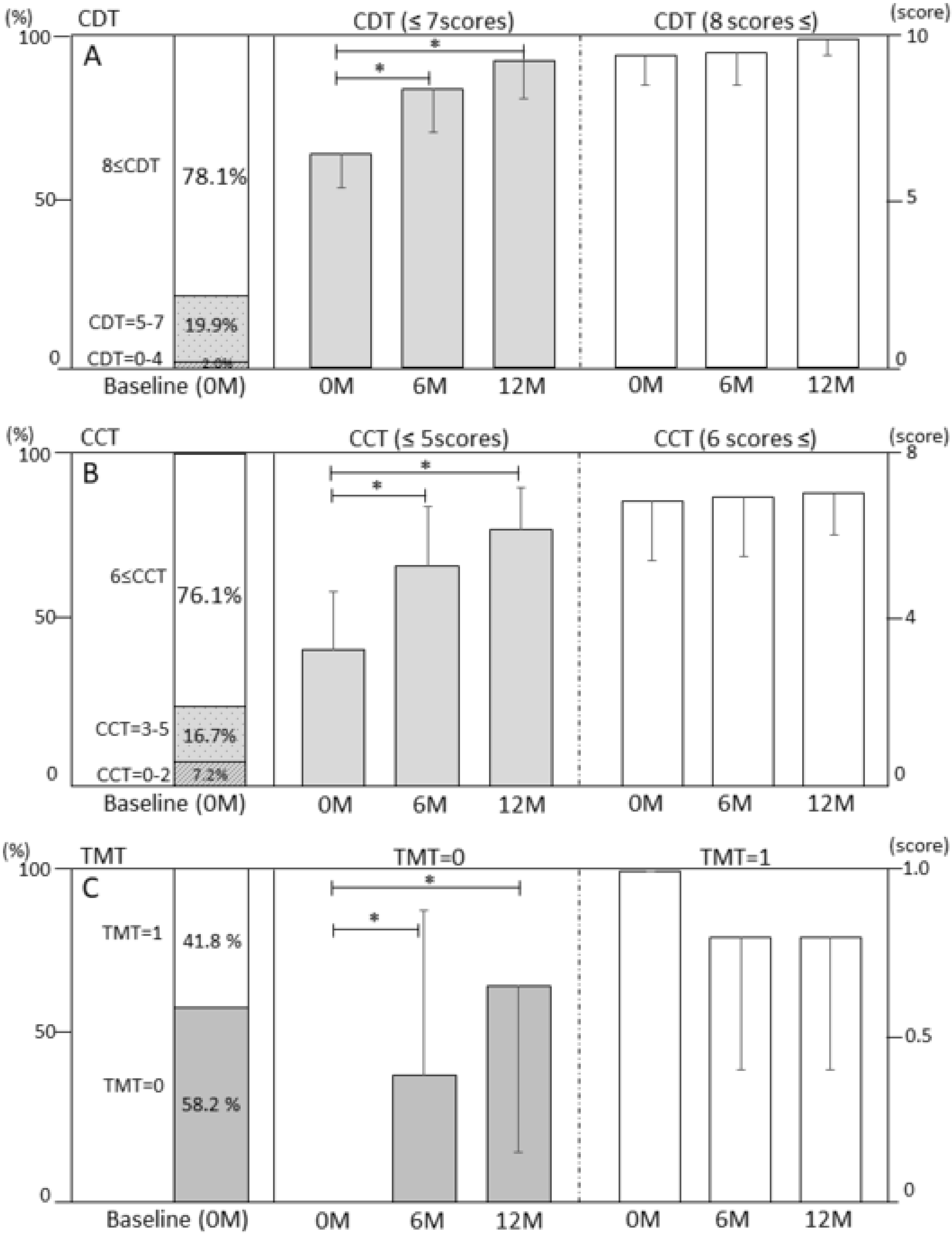


Figure 2



(%)
CDT
CDT (≤ 7scores)
CDT (8 scores ≤)
(score)
A
8≤CDT
78.1%
CDT=5-7
19.9%
CDT=0-4
Baseline (0M)
0M
6M
12M
*
CCT
CCT (≤ 5scores)
CCT (6 scores ≤)
B
6≤CCT
76.1%
CCT=3-5
16.7%
CCT=0-2
7.2%
TMT
TMT=0
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41.8 %
TMT=0
58.2 %

Figure3

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Figure 3

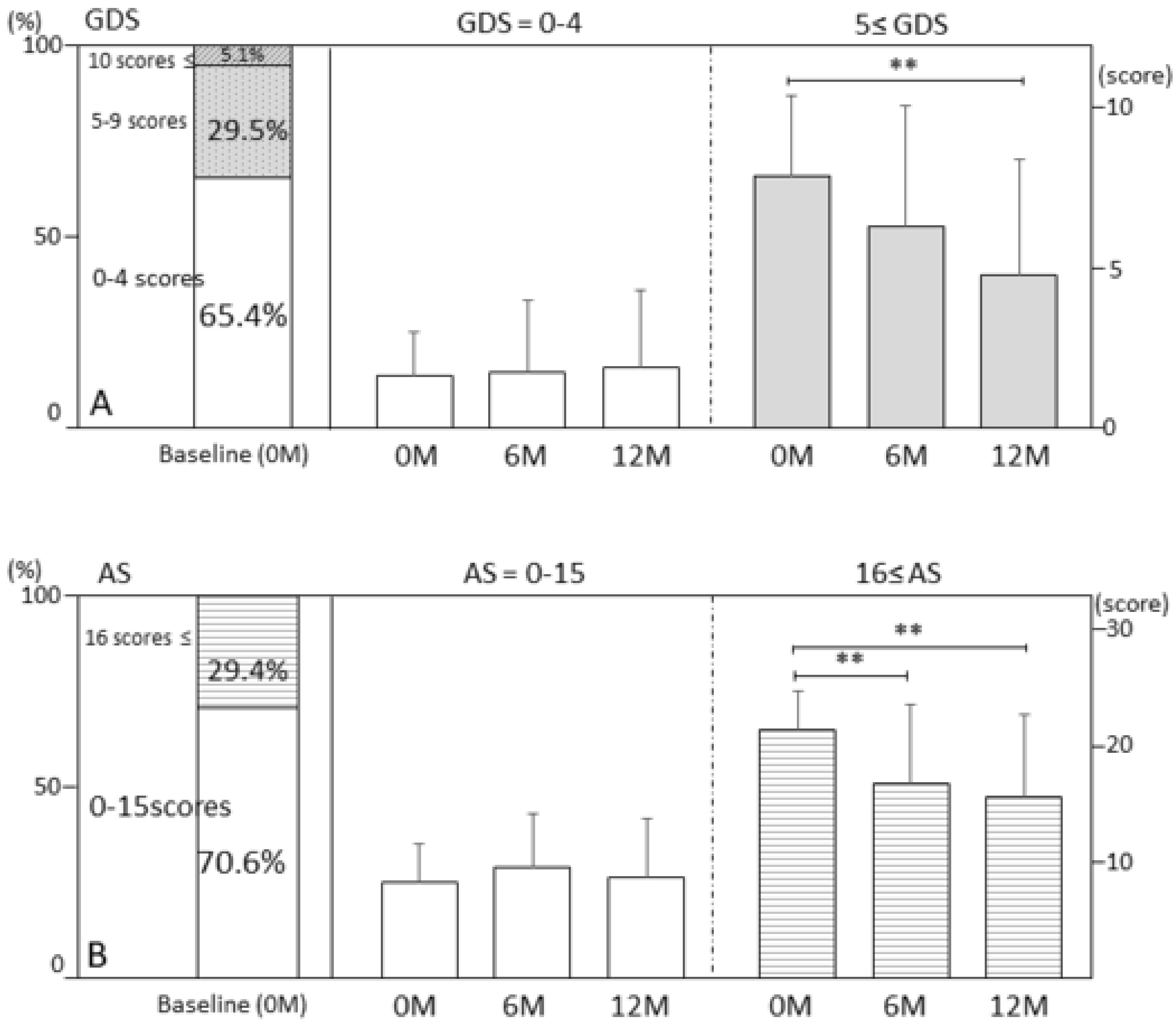

Table1

Table 1. Cognitive, affective, ADL, and physical functions at baseline and follow-up at 6M and 12M.

	No. of subjects	Baseline (0M)	6M	12M
Cognitive scores				
MMSE (/30)	67	21.7 ± 3.9	22.5.± 4.2	23.0.± 4.2
HDS-R (/30)	67	21.7 ± 4.9	21.8.± 4.8	23.0.± 4.3
FAB (/18)	67	10.7 ± 3.4	12.0 ± 3.6	13.3 ± 3.6**, #
Letter fluency (words)	295	7.8 ± 3.0	8.1 ± 3.2	8.5 ± 3.6**
Category fluency (words)	301	10.1 ± 3.5	10.5 ± 3.5	11.5 ± 3.7**, ##
CDT (/10)	251	8.6 ± 1.6	9.1 ± 1.3**	9.7 ± 0.7**, #
CCT (/8)	264	6.0 ± 1.7	6.4 ± 1.2*	6.7 ± 0.8**
TMT (/1)	263	0.5 ± 0.5	0.5 ± 0.5	0.5 ± 0.5
Affective scores				
GDS (/15)	332	3.2 ± 3.0	2.7 ± 3.2	2.7 ± 3.2
AS (/42)	347	12.3 ± 6.9	11.7 ± 6.5	10.0 ± 6.2
ABS (/44)	159	0.1 ± 0.4	0.3 ± 1.0	0.8 ± 2.6
ADL function score				
ADCS-ADL (/30) (n = 48)	48	21.9 ± 3.6	22.9 ± 2.9	22.2 ± 2.4
Physical tests				
Grasping power (right) (kg)	359	22.6 ± 7.5	23.1 ± 6.6	23.6 ± 6.4
Grasping power (left) (kg)	358	20.9 ± 7.1	21.3 ± 6.3	21.3 ± 6.5
Functional reach test (FRT) (cm)	68	16.5 ± 7.1	17.2 ± 8.5	17.4 ± 7.6
One leg standing time (sec)	325	28.1 ± 23.6	33.6 ± 23.7	36.2 ± 23.2**, ##
5m walking test (sec)	88	6.5 ± 3.0	6.3 ± 2.8	5.4 ± 1.4
3m up & go (3m TUG) (sec)	357	8.8 ± 5.1	7.9 ± 4.1	6.9 ± 2.8**, ##

Data represent mean ± SD. *p<0.05 and **p<0.01 vs baseline, #p<0.05 and ##p<0.01 vs 6M