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Comparison of dual-task and single-task in the prevention of cognitive decline, and the relationship between cognition and body composition

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Abstract: **The purpose of this study was to compare between the effects of a combination of exercise learning and passive learning on cognitive function before and after a six-month intervention. Body composition and vascular age were also correlated with cognitive function. Cognitive function was measured using the Montreal Cognitive Assessment. We also measured body composition with an inner scan monitor to examine its correlation with cognitive function. The results showed that the group that underwent the combination of exercise and learning exhibited significantly improved cognitive function compared to that that underwent passive learning. We also found a relationship between cognitive function and basal metabolic, bone mass, muscle mass, metabolic age, and vascular age.**

Keywords: **cognition, prevention, brain-exercises, dual-task, MoCA-test, body-composition, blood-age.**

I. INTRODUCTION

According to the Alzheimer's Society (2015), there are currently nearly 36 million people with dementia in the world; however, as many as 28 million of those living with dementia worldwide do not have a diagnosis. As a countermeasure against this, early preventive measures are needed before cognitive function begins to decline. Among the brain exercises purported to combat memory loss, dual-task exercises have been found to be more effective than single-task ones[1-3)].

Therefore, in this study, brain training using a dual-task exercise was performed in combination with a studying method. Elderly individuals who responded to our advertisement underwent a six-month intervention program that involved either a combination of physical exercise and learning or passive learning. Their cognitive functions were compared before and after the intervention.

In addition, although a relationship between physical exercise and cognitive function has been reported[4-6)], no study has related concrete body composition and cognitive function; only the relationship between muscle mass and cognitive function has been reported[7,8)]. Pathophysiological pathways are shared between age-related body composition changes and cognitive impairment. Therefore, not only muscle mass, but also changes in body composition are expected to have an effect on cognitive function.

This study also measured the body composition and vascular age of elderly participants and correlated them to cognitive function. Our results confirmed the exercise program improved both cognitive function and body composition.

II. METHODS

Intervention:

Dual-task: After performing warm up exercises that moved the hands and feet and an active dual-tasking game, a studying task was carried out.

Single-task: Only passive studying method was carried out.

The training lasted for six months, with a 90-minute session per month.

Participants were recruited through advertisements.

Measurement of cognitive function:

Japanese version of the Montreal Cognitive Assessment (MoCA-J)[9)]: This is a cognitive screening instrument developed to detect mild cognitive impairment (MCI). It assesses different cognitive domains: attention and concentration, executive functions, memory, language, visuoconstructional skills, conceptual thinking, calculations, and orientation. The time taken to administer the MoCA-J is approximately 10 minutes. The total possible score is 30 points; a score of 26 or above is considered normal.

Body composition monitors:

Inner scan monitor: The monitors use bioelectric impedance analysis (BIA) to monitor multiple components of overall health. Measurements include weight, body mass index (BMI), body fat, basal metabolic rate (BMR), metabolic age, bone mass, muscle mass, physique rating, and visceral fat rating.

Vascular age measurement system:

Measurement is performed by placing the finger on the sensor. Blood vessel age was measured by assessing the amount of blood flow between the first joint from the tip of the finger.

Time frame:

January to July 2015

Analysis:

The relationship between age and body composition with MoCA score was analyzed using Spearman's rank correlation coefficient. A paired t-test was used to compare the variables before and after the intervention.

Ethical considerations:

The outline of the research, voluntary nature of participation, anonymity, and agreement regarding the publication of the document were explained to prospective participants both in writing and verbally, and their consent was subsequently obtained. The study protocol was approved by the ethical review board of Nara Medical University and Gifu Junior College of Health Science.

III. RESULTS

Results of the MoCA:

There were 284 participants (75 male and 209 female), with an average age of 68.4 ± 8.3 years. Participants were assigned into either the dual-task group or single-task group. The MoCA was administered before and after the intervention and the average score of each item per age is given in Figs. 1–6.

The score on alternating trail making decreased with age ($r = -0.24$), but improved significantly after intervention in the dual-task group (dual-task group: $p = 0.011$, single-task group: n.s.). Visuoconstructional skills (Cube) was not correlated with age. Verbal fluency decreased slightly with age ($r = -0.18$). Although the scores increased after intervention, it was not significant (Fig. 1).

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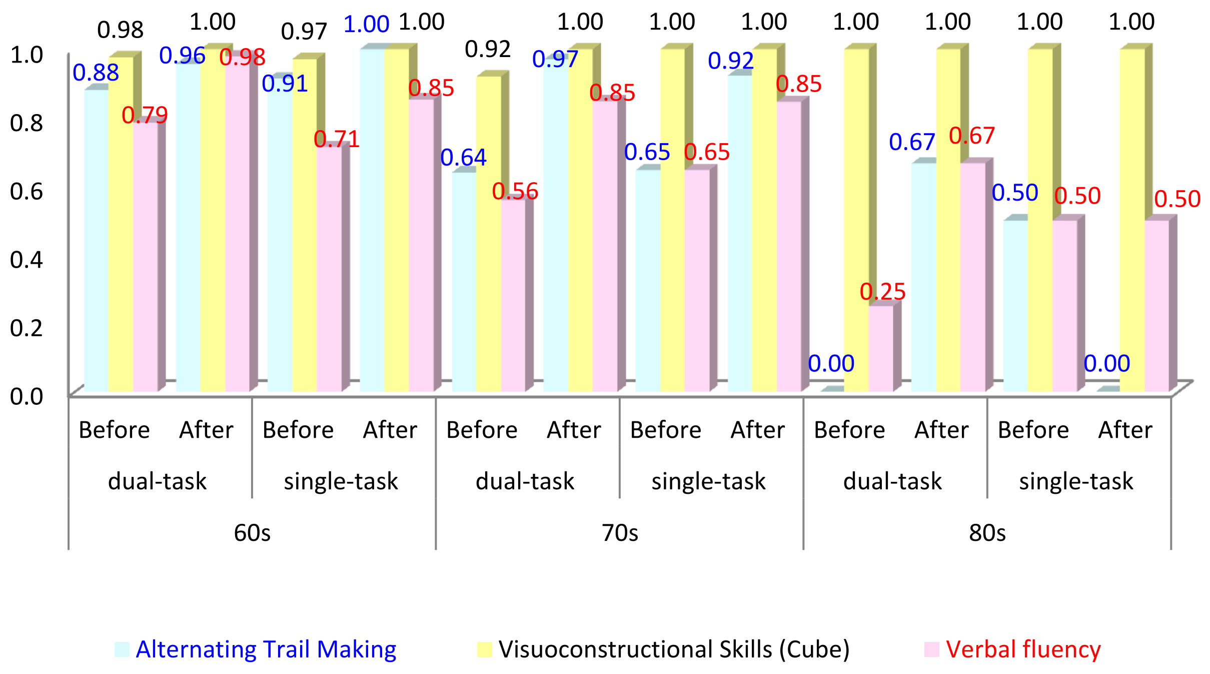

Figure 1: Average score on the MoCA test; 1-point scale

Scores on sentence repetition decreased mildly with age, but improved significantly after intervention (dual and single-task group: both p = 0.000). Abstraction did not decrease with age; scores on the task improved after the intervention (dual-task: p = 0.001, single-task: p = 0.017) :Fig. 2.

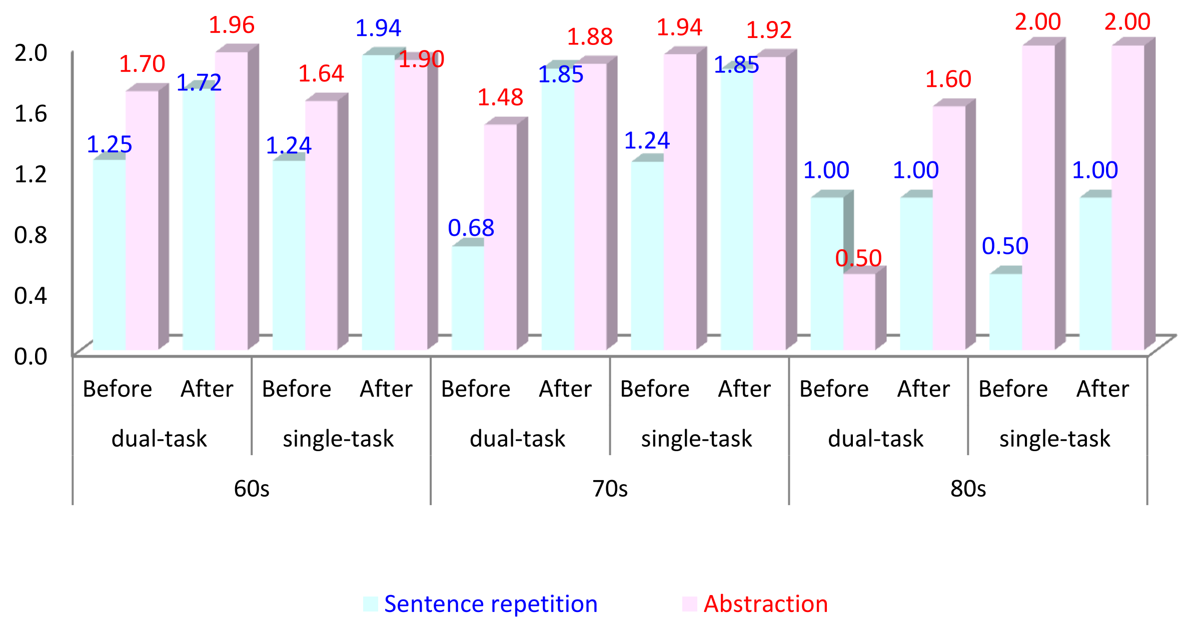

Figure 2: Average score on the MoCA test; 2-point scale

Visuoconstructional Skills (clock task) and naming were not decrease with age (n.s.). In addition, visuoconstructional skills (clock task) improved significantly after intervention (dual-task: p = 0.001, single-task: n.s.) :Fig. 3.

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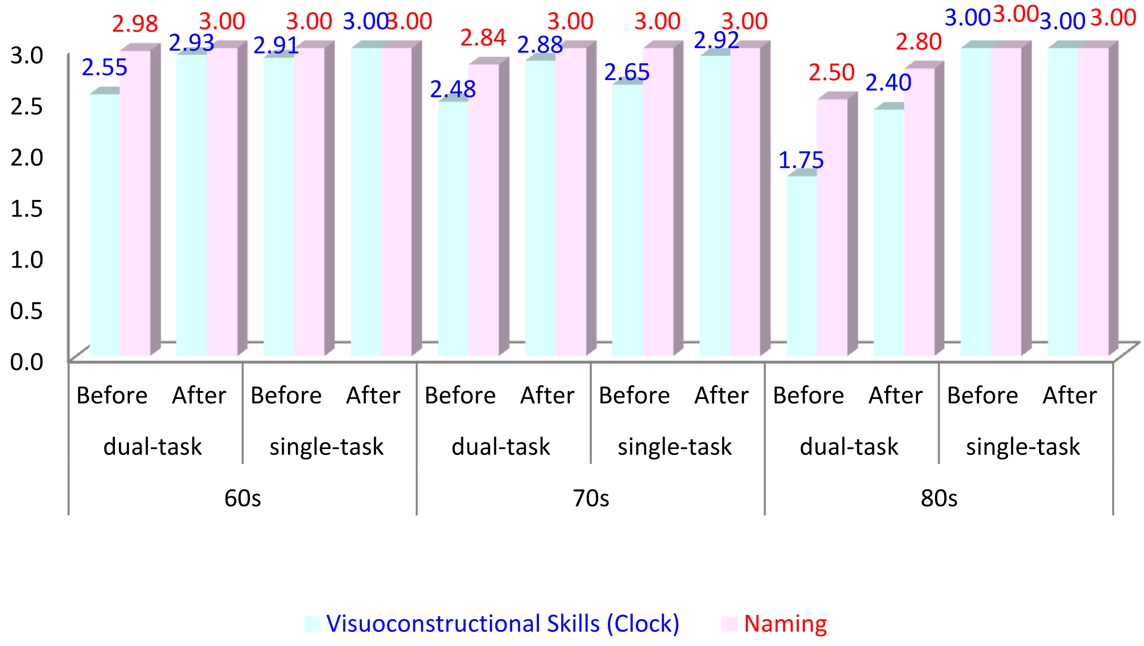

Figure 3: Average score on the MoCA test; 3-point scale

Delayed recall decreased with age (r = -0.33), but improved significantly after intervention (dual-task: p = 0.011; single-task: p = 0.007) :Fig. 4.

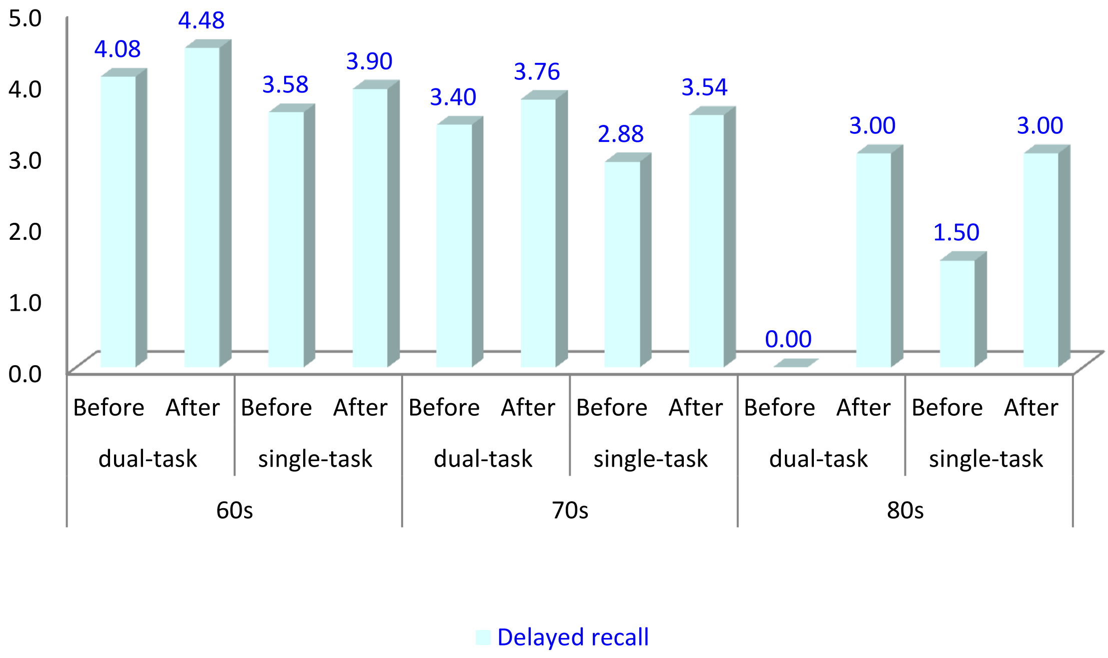

Figure 4: Average score on the MoCA test; 5-point scale

Attention and orientation were not decrease with age, attention was improved after the intervention (dual-task: p = 0.000; single-task: n.s.) :Fig. 5.

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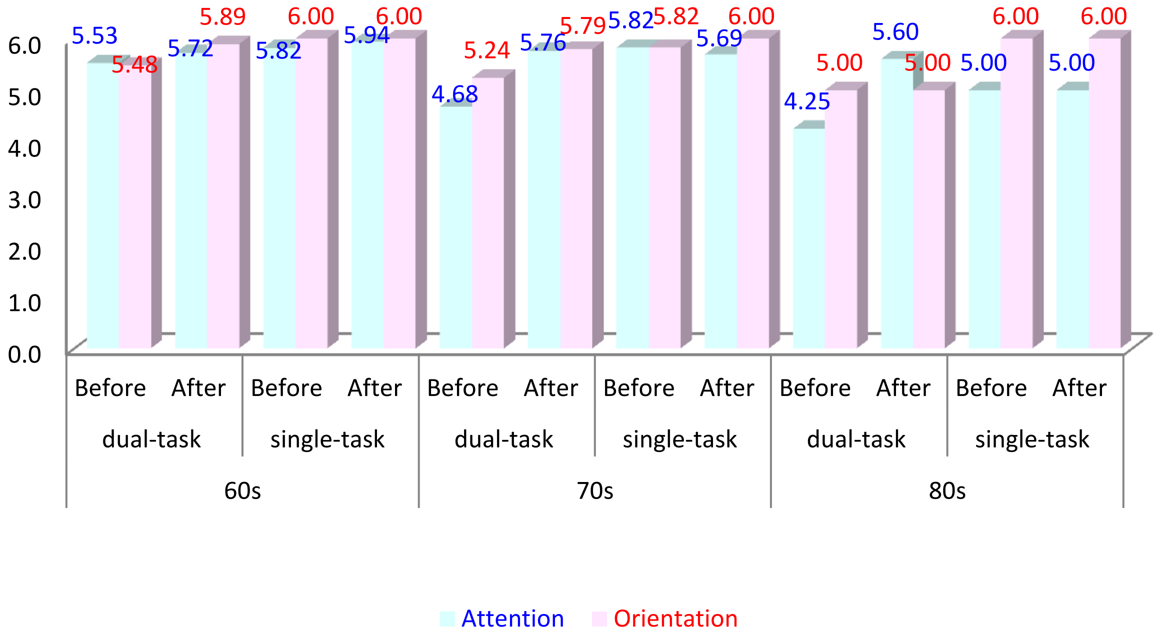

Figure 5: Average score on the MoCA test; 6-point scale

Although the total score decreased with age (r = -0.26), it improved by about 2–5 points across all ages after intervention (dual-task and single-task both p = 0.000) :Fig. 6.

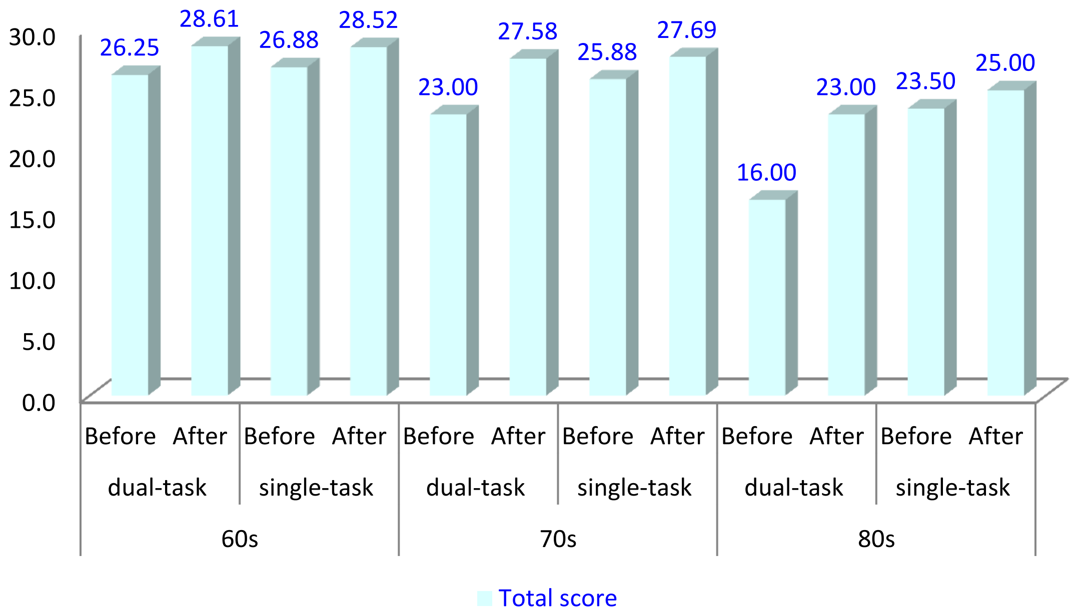

Figure 6: Average total score on the MoCA

Body Composition and Vascular Age:

The average values of body composition and blood age are shown in Table 1. MoCA score and the correlation between body composition and blood age are shown in Table 2.

Basal metabolism, bone mass, and muscle mass were positively correlated with MoCA score. Vascular age and metabolic age were negatively correlated with MoCA score.

Table 1: Average values of body composition and vascular age

Ages	Body mass index	Body fat	Muscle mass	Bone mass	Visceral fat rating	Basal metabolism	Metabolic age	Vascular age
60s	23.96	32.37	36.34	2.19	7.27	1119.94	58.85	63.07
70s	23.46	30.73	35.66	2.09	8.08	1079.33	65.17	68.96
80s	21.13	27.70	30.67	1.67	6.33	913.67	69.33	67.50

Table 2: Correlation between MoCA score and body composition and vascular age

MoCA test items	Correlations with body composition and vascular age (correlation coefficient)
Alternating Trail Making	Basal metabolism (0.27)
Visuoconstructional Skills (Clock)	Bone mass (0.26)
Attention	Bone mass (0.26), Vascular age (-0.34)
Sentence repetition	Bone mass (0.28), Muscle mass (0.25), Basal metabolism (0.27)
Verbal fluency	Metabolic age (-0.28)
Abstraction	Metabolic age (-0.28)
Delayed recall	Metabolic age (-0.29), Vascular age (-0.35)
Orientation	Vascular age (-0.42)
Total score	Basal metabolism (0.25), Bone mass (0.28), Muscle mass (0.27), Vascular age (-0.39)

Spearman's rank correlation coefficient

IV. DISCUSSION

Most of the cognitive functions tested in the MoCA declined with age. However, visuoconstructional skills, abstraction, naming, attention, and orientation showed lower age-related changes. This indicates that functions related to the creation of new memories and processing deteriorate with aging, but the reproduction of old memories and everyday thinking are maintained. Functions related to new memory and processing were declining with age, but recovered after brain exercises. In brain exercises, the combination of learning and active dual-task exercise was more effective than passive single-learning.

Although the single-task exercise has been found to be effective [10,11)], adding a physical exercise task increases cerebral blood flow[12)], hippocampal volume[5)], brain-derived neurotrophic factor[13)], and angiogenesis[14)]. Furthermore, cognitive function improves more with a dual-task exercise that encourages physical exercises while thinking[15,16)]. This study also verified that the active dual-task exercise significantly and widely improved cognitive function.

In the correlation between body composition and cognitive function, basal metabolism, bone mass, and muscle mass increased with score on cognitive function. In contrast, vascular age and metabolic age were negatively correlated with score on cognitive function. Previous studies have also found a correlation between muscle mass and cognitive function[17)]. In addition, the correlation between bone mineral density and cognitive function has been reported[18)]. The relationship between vascular risk and cognitive function is well-known[19, 20)]; indeed, this study also found the highest correlation coefficient for MoCA total score and vascular age.

Therefore, in order to maintain cognitive function, it is necessary to have dietary habits that maintain basal metabolism, bone mass, and muscle mass. To maintain vascular age and metabolic age, it is necessary to prevent obesity and atherosclerosis. For this reason, the active dual-task exercise is also recommended.

V. CONCLUSION

This study compared the effects of the active dual-task exercise and passive learning and found that dual-task exercise was more effective across many domains of cognitive function.

Regarding the relationship between body composition and cognitive function, we found correlations with basal metabolism, bone mass, muscle mass, metabolic age, and vascular age.

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