



Original Article

## Identifying elderly people at risk for cognitive decline by using the 2-step test

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**Abstract.** [Purpose] The purpose is to verify the effectiveness of the 2-step test in predicting cognitive decline in elderly individuals. [Subjects and Methods] One hundred eighty-two participants aged over 65 years underwent the 2-step test, cognitive function tests and higher level competence testing. Participants were classified as Robust, <1.3, and <1.1 using criteria regarding the locomotive syndrome risk stage for the 2-step test, variables were compared between groups. In addition, ordered logistic analysis was used to analyze cognitive functions as independent variables in the three groups, using the 2-step test results as the dependent variable, with age, gender, etc. as adjustment factors. [Results] In the crude data, the <1.3 and <1.1 groups were older and displayed lower motor and cognitive functions than did the Robust group. Furthermore, the <1.3 group exhibited significantly lower memory retention than did the Robust group. The 2-step test was related to the Stroop test ( $\beta$ : 0.06, 95% confidence interval: 0.01–0.12). [Conclusion] The finding is that the risk stage of the 2-step test is related to cognitive functions, even at an initial risk stage. The 2-step test may help with earlier detection and implementation of prevention measures for locomotive syndrome and mild cognitive impairment.

**Key words:** The 2-step test, Cognitive functions, Community-dwelling elderly individuals

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### INTRODUCTION

Every three seconds, an individual is diagnosed with Alzheimer's disease worldwide. In 2015, there were 46.8 million individuals with dementia; this number is projected to reach 74.7 million in 2030 and 131.5 million in 2050<sup>1)</sup>. In Japan in 2016, dementia became the most common reason for nursing care. On the other hand, musculoskeletal disorders such as osteoarthritis and fractures are most common reasons prior to needing nursing care<sup>2)</sup>. The prevalence of dementia and musculoskeletal disorders increase with aging<sup>3, 4)</sup>. Accordingly, with an increasingly aging population, it is expected that the prevalence of these disorders will increase as well. The Ministry of Health, Labor and Welfare has stated the need to “increase the detection of elderly people who have a high risk for cognitive decline” and “increase the recognition of ‘locomotive syndrome’.” Locomotive syndrome is a restricted ability to walk or lead a normal life owing to a dysfunction in one or more of the parts of the musculoskeletal system<sup>5)</sup>. Altogether, prevention of dementia and locomotive syndrome is the most important task concerning health promotion in Japan.

Recently, reports have indicated that cognitive function is related to motor function<sup>6, 7)</sup>. Mild cognitive impairment (MCI), a precursor of dementia<sup>8)</sup>, is associated with low gait function<sup>9)</sup>. Additionally, subjects who have both cognitive and motor decline have a higher risk of falling<sup>10, 11)</sup>. We have reported that subjects with MCI have low 2-step test values, indicative of locomotive syndrome; this remained true even after adjustment for age and years of education<sup>12)</sup>. Thus, subjects with

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locomotive syndrome may also have decreased cognitive function. Moreover, Yoshimura reported that MCI significantly increased the risk of incident radiographic knee osteoarthritis<sup>13</sup>. However, the relationship between locomotive syndrome and cognitive function remains unclear. The 2-step test is used to test for locomotive syndrome. However, the potential relationship between the 2-step test and cognitive functions is unclear. The aim of this study was to investigate the relationship between cognitive function and the severity of locomotive syndrome as evaluated using the 2-step test. The results obtained in this study will help to develop a simple test for improving identification of elderly people at high risk for cognitive decline.

## SUBJECTS AND METHODS

One hundred and eighty-two community dwelling elderly individuals aged over 65 years (average, 73.9 years) were recruited in a dementia prevention class. All participants were able to attend the class and complete evaluations. The study was approved by the ethics board of the Faculty of Health and Medical Care, Saitama Medical University (No.137), and participants provided informed consent.

The 2-step test was conducted in accordance with the methods of Muranaga et al<sup>14</sup>. Participants were asked to take two consecutive steps as far forward as possible and to place stop at the second step. Retesting was performed if participants lost balance during the test or if they did not stop after the second step. In addition, participants were forbidden from jumping. The test was carried out until two results were obtained. The maximum value was selected and divided by the participant's height. The result of the 2-step test value was categorized as Robust ( $\geq 1.3$ ),  $< 1.3$ , and  $< 1.1$ , according to Japanese Orthopedic Association criteria<sup>5</sup>).

Height, weight, education years, and frequency of physical activity were surveyed using a questionnaire. Questions regarding physical activity asked about walking frequency per week and physical activity excluding walking frequency. For analysis, the frequency of physical activity was dichotomized into two categories,  $< 1$  day per week and  $\geq 1$  day per week.

Participants were measured comfortable walking speed. The time required for participants to walk 6 meters along a straight walking path at a comfortable speed was measured using a stopwatch, and the walking speed was calculated.

Participants memorized five unrelated pictures and were asked to recall them after the color Stroop test as a disturbance stimulus. The Stroop test consisted of 20 Power Point slides as described by Hosoda et al<sup>15</sup>. The time to complete the slides was measured using a stopwatch, after which participants were asked to recall the pictures as accurately and quickly as possible. Participants received 2 points if they could remember the picture without a hint. If they could remember following a hint, they received 1 point. Possible scores ranged from 0 to 10 points. The Rapid Dementia Screening Test for Japanese (RDST-J)<sup>16</sup> consists of a word frequency task and a numeral mutual conversion task. In the word frequency task, participants recorded as many supermarket and convenience store goods as possible in 1 minute. In the mutual conversion task, participants completed four tasks wherein they converted Arabic and Chinese numerals. For this study, the total score calculated from both tasks was used for analysis, and participants were considered to have cognitive decline if they scored less than 8 total points. The Japan Science and Technology Agency Index of Competence to Assess Functional Capacity (JST-IC) was created to measure higher level competence according to Lawton's hierarchical model of competence. The JST-IC can measure the competencies required for older individuals living alone to become independent and lead an active daily life within the living environment of the modern active older citizen<sup>17</sup>. The JST-IC consists of four categories regarding 'using new machines', 'information gathering', 'management of living', and 'social participation'. Each category has four questions that can be answered "Yes" or "No". Scores range from 0 to 16 points, with higher scores indicating higher competence.

Participant characteristics, motor functions, cognitive functions, and JST-IC scores were compared between the three 2-step test result groups. One-way analysis of variance (ANOVA) with a Tukey post-hoc multiple comparison test was used for continuous variables, and the  $\chi^2$  test was used for categorical variables (Model 1). In addition, analysis of covariance (ANCOVA), with adjustment for age, body mass index (BMI), walking frequency, and education years, was used for comparison of walking speed, cognitive functions, and JST-IC (Model 2). Groups based on RDST-J scores were compared with the 2-step test risk stage groups using the  $\chi^2$  test.

Furthermore, ordered logistic analysis was used to analyze cognitive functions as independent variables, using the three groups based on 2-step test results as the dependent variable, with ordered adjustment for age, gender, education years, BMI, and walking frequency. JMP ver.13.0 for Mac (SAS Institute Inc. USA) was used as analysis software, and the level of significance was set at 5%.

## RESULTS

Table 1 shows the comparison between groups. In Model 1 (ANOVA results), the average age was significantly higher with a lower 2-step test value. Participants in the  $< 1.1$  group had a significantly higher BMI than those in other groups. Walking speed decreased significantly with a lower 2-step test value. The Robust group was faster in the Stroop test than that in the other groups. Word frequency and RDST-J scores in the  $< 1.3$  and  $< 1.1$  groups were significantly lower. JST-IC was similarly low in both the  $< 1.3$  and  $< 1.1$  groups. Gender, education years, physical activity, and memory retention test results were not significantly different between groups.

In Model 2, ANCOVA adjusted for age, BMI, walking frequency, and education years showed that walking speed decreased

**Table 1.** Comparison of characteristics, cognitive functions, and motor functions in each group based on the 2-step test value

Model 1. Crude	Robust: a (n=130)	<1.3: b (n=40)	<1.1: c (n=12)	significance
Age, years	72.7 (4.8)	76.5 (6.8)	78.6 (4.9)	a<b,c
Female, n (%) <sup>§</sup>	111 (85.4)	34 (85.0)	11 (91.7)	
BMI, kg/m <sup>2</sup>	21.9 (2.7)	22.4 (3.2)	25.8 (2.9)	a,b<c
Education, years <sup>§</sup>	11.9 (2.0)	12.1 (2.0)	11.6 (1.4)	
Walking frequency ≥1 d/w, n (%)	94 (72.3)	20 (50.0)	5 (41.7)	**
PA frequency ≥1 d/w, n (%) <sup>§</sup>	65 (50.0)	20 (50.0)	5 (41.7)	
WS, m/s	1.43 (0.21)	1.22 (0.21)	1.08 (0.23)	b,c<a
Memory retention, point	9.6 (0.8)	9.1 (1.5)	9.6 (0.7)	
Stroop, sec	31.2 (12.2)	37.4 (15.0)	38.2 (10.0)	a<b,c
Word frequency, words	13.5 (3.6)	10.7 (3.9)	10.4 (3.4)	b,c<a
RDST-J score, point	9.8 (2.1)	8.0 (2.6)	7.7 (2.8)	b,c<a
JST-IC, point	12.0 (2.9)	10.5 (2.5)	9.8 (2.7)	b,c<a

  

Model 2. Adjusted	Robust: a (n=130)	<1.3: b (n=40)	<1.1: c (n=12)	significance
BMI, kg/m <sup>2†</sup>	22.0 (0.3)	22.4 (0.5)	25.3 (0.9)	a,b<c
WS, m/s	1.44 (0.02)	1.27 (0.03)	1.10 (0.07)	c<a,b
Memory retention, point	9.6 (0.1)	9.1 (0.2)	9.9 (0.3)	b<a
Stroop, sec	31.0 (1.4)	33.1 (2.7)	36.2 (4.8)	
Word frequency, words	13.1 (0.4)	12.0 (0.6)	11.5 (1.1)	
RDST-J score, point	9.5 (0.2)	8.7 (0.4)	8.5 (0.7)	
JST-IC, point	11.7 (0.3)	10.9 (0.5)	9.9 (0.9)	

Model 1.

Mean (Standard deviation), \*\*p<0.01, One way analysis of variance, post hoc multiple comparison analysis by Tukey, <sup>§</sup>χ<sup>2</sup> test.

Model 2.

Estimator (standard error), analysis of covariance, post hoc multiple comparison analysis by Tukey. Adjusted by age, BMI, walking frequency, education years, <sup>†</sup>Adjusted by age, walking frequency, education years.

BMI: body mass index; PA: physical activity; WS: walking speed; Stroop: the shortened version of color Stroop test; RDST-J: the rapid dementia screening test-Japanese; JST-IC: the Japan Science and Technology Agency Index of Competence to Assess Functional Capacity.

**Table 2.** The prevalence of cognitive decline for each group based on the 2-step test values

	Robust (n=130)	< 1.3 (n=40)	< 1.1 (n=12)
Cognitive decline	17 (13.2)	15 (38.5)	5 (41.7) <sup>***</sup>
Normal	113 (86.8)	25 (61.5)	7 (58.3)

Data is number of patients (%), χ<sup>2</sup> analysis, \*\*\*p<0.001.

Cognitive decline was determined by the rapid dementia screening test Japanese of cut-off point (7 points or less).

with a lower 2-step test value and that retention was lower in the <1.3 group than that in the Robust group. The prevalence of cognitive decline was higher in the <1.3 and <1.1 groups classified by the 2-step test than in the Robust group (Table 2).

In the ordered logistic analysis, only Stroop test scores were associated with 2-step test values (β: 0.06, 95% confidence interval: 0.01–0.12, p=0.02).

## DISCUSSION

This study investigated the relationship between cognitive functions and the severity of locomotive syndrome as measured using the 2-step test. Participants with worse 2-step test values (<1.3 and <1.1) were older and had a higher BMI and lower motor and cognitive functions than those in the Robust group (Model 1). However, cognitive functions and motor functions are related to ageing. In addition, it is thought that while cognition is related to education years, motor function is more related to BMI and physical activity. Therefore, ANCOVA (Model 2) was analyzed adjusted by age, BMI, education years and walking frequency. Significant results in the ANCOVA were limited to walking speed and the memory retention test,

both of which were lower in the <1.3 group than those in the Robust group. Although it did not reach statistical significance, Stroop test time worsened with a lower 2-step test value. In addition, there was a higher prevalence of cognitive decline in both the <1.3 and <1.1 groups than that in the Robust group. As a 2-step test value of <1.3 suggests a decline in locomotive functions<sup>5)</sup>, the present results suggest that participants might have cognitive decline although a decline in motor functions was not severe.

In a study by Narita et al., community-dwelling elderly participants, with RDST-J values less than the same cut-off point as used in the present study, were older and had slower gait speed<sup>18)</sup>. We verified whether participants with or without MCI had differences in walking speed and 2-step test values adjusted for age and education years and found that MCI was associated with a significantly lower 2-step test value, although walking speed was not<sup>12)</sup>. As the 2-step test reflects walking ability and can easily be conducted in a limited space such as an examination room<sup>14)</sup>, these results suggest that the 2-step test may be a useful screening tool for early detection of MCI and musculoskeletal disorders. However, 13.2% of participants in the Robust group were false positive. Furthermore, 61.5% and 58.3% of participants in the <1.3 and <1.1 group were false negative. Therefore the predicting rate of the 2-step test value was low. It is required attention to use the results for a distinction between MCI or not.

It has been suggested that the association between the decline in 2-step test results and cognitive functions results from the negative influence of lower cognitive function on physical activity. Conversely, Tanigawa et al. has reported that lower physical activity may be a risk factor for cognitive decline<sup>19)</sup>. Furthermore, lower physical activity is associated with overweight or obesity, and obesity is associated with a decrease in cognitive functions<sup>20)</sup>. In this study, walking frequency was 41.7–50.0% in the <1.3 and <1.1 groups, while it was 72.3% in the Robust group. Low cognitive functions were found among the <1.3 and <1.1 groups. Therefore, there appears to be a reciprocal relationship between cognitive decline and lower physical activity, with declines in one variable leading to declines in the other. In addition, Kose et al. studied the relationship between the Timed Up and Go test (TUG) results, brain atrophy at medial temporal areas, and cognitive functions. They found that lower TUG performance was related to poor performance on the trail-making test and was associated with severe medial temporal atrophy in community-dwelling elderly adults<sup>21)</sup>. This is consistent with the present results in which a lower 2-step test performance was associated with lower memory retention and may suggest brain atrophy in these participants.

In addition, Stroop test results were independently associated with age, gender, BMI, education years, and walking frequency, suggesting that a faster time on the Stroop test, which measures executive functions (such as inhibition) in the frontal lobe<sup>22)</sup>, is associated with a higher probability of being in the Robust group. In the 2-step test, stopping at the second step without proceeding to the third step can be thought to represent an inhibition function, which has been associated with motor functions<sup>23)</sup>. Furthermore, Yokokawa et al. reported that participants with slow Stroop test times had a significantly lower stride and walking speed during dual task walking<sup>24)</sup>.

Moreover, Brodaty et al. reported that the transition ratio to Alzheimer disease over 2 years was 1.1% with no cognitive impairment and 1.1–9.1% with MCI. Additionally, the reversion ratio from MCI to no cognitive impairment was 5.0–44.4%<sup>25)</sup>. Therefore, it is necessary to discover and manage MCI earlier. However, Petersen et al.<sup>8)</sup> suggested that individuals with MCI, although they can complete basic activities of daily living, have some complications. On the contrary, in the current study, there was no significant difference regarding high-level competency. For this reason, it is suggested that typical community-dwelling people, without the expertise to identify MCI, do not recognize individuals with MCI. In addition, individuals are resistant to have their cognitive functions measured, and it consumes a considerable amount of time to measure. However, the 2-step test is simple and does not require specialized tools or knowledge and requires only a short time to conduct. Prevention of dementia and locomotive syndrome is the most important task concerning health promotion in Japan. Thus, if the 2-step test is used as a pre-screening test, in addition to screening for locomotive syndrome, it might also be able to help identify individuals with MCI. This may help lead to earlier interventions for at-risk individuals.

The main limitation of this study is that it was unable to clarify a causal relationship between a reduction in 2-step test results and a decline in cognitive functions because it was cross-sectional. In addition, only participants who joined a preventive care class were recruited, and there were relatively few participants. Thus, whether these results can be applied to the general population of community-dwelling elderly people is uncertain. There is a need to conduct further longitudinal studies.

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