Japanese version of the Montreal Cognitive Assessment cut-off score to clarify improvement of mild cognitive impairment after exercise training in community-dwelling older adults

Marina Nara,1,2 Masamitsu Sugie,1,3 Tetsuya Takahashi,1,4 Teruyuki Koyama,5 Renpei Sengoku,6 Yoshinori Fujiwara,7 Shuichi Obuchi,1,8 Kazumasa Harada,1,3 Shunei Kyo9 and Hideki Ito10

Departments of 1Health Promotion, 3Cardiology, 5Rehabilitation, 6Neurology, 9Cardiac Surgery, 10Diabetes, Metabolism and Endocrinology, Tokyo Metropolitan Geriatric Hospital and Institute of Gerontology, 2Health Management Services Inc., 4Department of Physical Therapy, School of Health Science, Tokyo University of Technology, Research Team for Social Participation and Community Health, 7Tokyo Metropolitan Institute of Gerontology, and 8Research Team for Promoting Support System for Home Care, Tokyo, Japan

Aim: Physical exercise improves cognitive function in people with mild cognitive impairment (MCI). However, information about whether the degree of MCI before exercise training affects improvement in cognitive function is lacking. Therefore, we aimed to investigate the cut-off value in a MCI screening tool that predicts reversal to normal cognitive function after exercise training in older adults with MCI.

Methods: Participants included 112 Japanese community-dwelling older adult outpatients (37 men, 75 women; mean age 76.3 years). We administered the Japanese version of the Montreal Cognitive Assessment (MoCA-J) before and after exercise training. MCI was defined as a MoCA-J score <26. All participants underwent exercise training 2 days per week for 6 months, according to American Heart Association guidelines.

Results: The prevalence of MCI was 65.2%. After exercise training, 46.6% of participants with MCI reversed to normal cognitive function. The MoCA-J cut-off score to predict cognitive function potentially reversible to normal was 23, with receiver operating characteristic analysis showing an area under the curve of 0.80, sensitivity of 79.4% and specificity of 69.2%. Multiple logistic regression analysis to predict non-MCI after exercise training showed that MoCA-J score ≥ 23 (OR 6.9, P < .001), female sex (OR 3.4, P = .04) and age (OR 0.9, P = .04) were independent determinants.

Conclusions: The MoCA-J cut-off score of 23 might be useful to predict cognitive function that is potentially reversible to normal among community-dwelling Japanese older adults with MCI. Geriatr Gerontol Int 2018; 18: 833–838.

Keywords: cognitive function, community-dwelling older adults, exercise training, mild cognitive impairment, Montreal Cognitive Assessment.

Introduction

Mild cognitive impairment (MCI) is an intermediate clinical state between normal cognitive aging and dementia.1 MCI has a high risk of progressing to dementia among older adults. The conversion rate of MCI to Alzheimer’s disease is 10–12% per year.2,3 However, a previous study reported that MCI could be reversed to normal cognition.4 Grande et al found that people who reverted to normal cognition from MCI had better global cognition.5

Physical exercise improves cognitive function in people with MCI.6–8 However, other reports have shown that physical exercise has no positive effect on cognitive function.9 These contradictory reports suggest that there are responders and non-responders of cognitive function to physical exercise therapy. Therefore, we hypothesized that there might be a MCI cut-off point that dictates whether cognitive function improves with exercise training in community-dwelling older adults.
The Montreal Cognitive Assessment (MoCA) is a MCI screening tool that has higher sensitivity and specificity for detecting MCI than the Mini-Mental State Examination. In addition, the Japanese version of the MoCA (MoCA-J) is a useful cognitive test with good reliability and validity. Clarifying a cut-off value might be useful to predict the responsiveness of MCI improvement by exercise training. This could help clinical decision-making about exercise training or medication. Therefore, we aimed to investigate a MoCA-J cut-off value that could clarify improvement of MCI by physical exercise training among community-dwelling older adults.

Method

Participants

The present prospective and longitudinal study was carried out from January 2015 to July 2017. All participants were stable outpatients of the Tokyo Metropolitan Geriatric Hospital and Institute of Gerontology, Tokyo, Japan. Participants were recruited through the hospital bulletin board. To be enrolled, the candidates should meet all the requirements as follows: they should be aged ≥65 years, able to come to the research site on their own, currently un-hospitalized, and all were receiving outpatient treatment at the Tokyo Metropolitan Geriatric Hospital and Institute of Gerontology, exempt from physical movement restrictions ordered by their primary doctor.

In total, 112 community-dwelling individuals participated in this study. Exclusion criteria were: impaired vision, impaired hearing, musculoskeletal impairments that might interfere with the ability to carry out exercise training, a clinically unstable condition, diagnoses of dementia, Alzheimer’s disease or Parkinson’s disease, and treatment with cilostazol and donepezil. Potential participants that habitually carried out exercise training were also excluded from the study. Participants’ clinical characteristics are summarized in Table 1.

Assessment of cognitive function

We assessed cognitive function for all participants using the MoCA-J before and after the 6-month exercise training program. MoCA-J scores range from 0 to 30, with higher scores indicating better cognitive performance. We defined MCI as a MoCA-J score <26 points, which is a clinical cut-off value for MCI.

Exercise training program

The multicomponent exercise session included warm-up, cool down and flexibility exercises. In each session, participants completed 30 min of submaximal aerobic exercise with cycling training at a Borg rating of 13 (somewhat hard), and 15 min of submaximal resistance training (knee extension, hip abduction, rowing, leg press) at 50–70% of one repetition maximum. Participants underwent one exercise session for 2 days per week over a 6-month period. Training was carried out according to the American Heart Association’s guidelines.

Statistical analysis

Before the exercise training program, we divided participants into the non-MCI group (MoCA-J ≥26) and the MCI group (MoCA-J <26). After exercise training, we again divided participants into non-MCI and MCI groups. We compared the mean values for the characteristics and prevalence between the non-MCI and MCI groups using Student’s t-tests and χ²-tests at baseline (before exercise training). McNemar χ²-tests were used to compare the change of MCI prevalence in each group before and after the exercise training program. To predict cognitive function potentially reversible to normal (potentially reversible group) and cognitive function potentially irreversible to normal (potentially irreversible group) after exercise training, we calculated the area under the curve in receiver operating characteristic curves using the MoCA-J score at baseline. We carried out logistic regression analysis to predict cognitive function that reversed from MCI (MoCA-J score <26) to normal cognition (MoCA-J score >25) using the reversible MoCA-J cut-off score adjusted for potential confounders (age, sex, hypertension, diabetes mellitus, dyslipidemia, atrial fibrillation, coronary artery disease, chronic heart failure). All statistical analyses were carried out with SPSS Version 22 (IBM Japan, Tokyo, Japan). The significance level was set at P = 0.05 for all tests.

Ethical considerations

This study was approved by the ethics committee of the Tokyo Metropolitan Geriatric Hospital and Institute of Gerontology (authorization number: 240301). All participants provided written informed consent before data collection.

Results

There were 73 older adults with MCI (65.2%) among the 112 community-dwelling older adult outpatients. At baseline, the MoCA-J score was significantly different between the non-MCI group (27.7 ± 1.0 points) and the MCI group (22.3 ± 2.5 points). In addition, there were significant differences in age, sex, and the prevalence of diabetes mellitus between the non-MCI and MCI groups (Table 1).

After the 6-month exercise training program, 34 participants with MCI (46.6%) showed an improved MoCA-J score (>26 points). There was only one participant in the non-MCI group that converted to MCI after the exercise training program (Table 2). The receiver operating characteristic analysis showed that the cut-off...
| Table 1  | Characteristics of participants with and without mild cognitive impairment at baseline |
|----------|-------------------------------------------------------------------------------------|
|          | All (112) | Non-MCI (39) | MCI (73) | P-value |
| Age (years) | 76.30 ± 6 | 74.54 ± 5.17 | 77.3 ± 6.23 | 0.02 |
| Sex       |           |             |          | <0.05 |
| Male      | 37 (33%)  | 6 (15%)     | 31 (42%) |       |
| Female    | 75 (67%)  | 33 (85%)    | 42 (58%) |       |
| MoCA-J score | 24.1 ± 3.3 | 27.7 ± 1.0 | 22.3 ± 2.5 | <0.01 |
| Type of illness, n (%) | | | | |
| Hypertension | 45 (40%) | 19 (17%) | 26 (33%) | NS |
| Diabetes mellitus | 89 (79%) | 26 (23%) | 63 (86%) | 0.03 |
| Hyperlipidemia | 72 (64%) | 23 (21%) | 49 (66%) | NS |
| Atrial fibrillation | 105 (94%) | 39 (35%) | 66 (59%) | NS |
| Coronary artery disease | 92 (82%) | 30 (27%) | 62 (55%) | NS |
| Chronic heart failure | 104 (93%) | 38 (34%) | 66 (59%) | NS |
| Cerebral infarction | 102 (91%) | 37 (33%) | 65 (58%) | NS |
| Medication, n (%) | | | | |
| Calcium blocker | 43 (38%) | 15 (13%) | 28 (25%) | NS |
| Angiotensin converting enzyme inhibitor | 11 (10%) | 3 (3%) | 8 (7%) | NS |
| Angiotensin II receptor blocker | 29 (26%) | 9 (8%) | 20 (18%) | NS |
| Beta blocker | 26 (23%) | 5 (4%) | 21 (19%) | NS |
| Statin | 28 (25%) | 9 (8%) | 19 (17%) | NS |
| Insulin | 1 (1%) | 1 (1%) | 0 (0%) | NS |
| Sulfonylureas | 3 (3%) | 2 (2%) | 1 (1%) | NS |
| Biguanides | 5 (4%) | 3 (3%) | 2 (2%) | NS |
| Alpha-glucosidase inhibitors | 4 (4%) | 3 (3%) | 1 (1%) | NS |
| Dipeptidyl peptidase-4 | 9 (8%) | 5 (4%) | 4 (4%) | NS |
| Prednisolone | 3 (3%) | 0 (0%) | 3 (3%) | NS |
| Aspirin | 28 (25%) | 6 (5%) | 22 (20%) | NS |
| Warfarin | 5 (4%) | 0 (0%) | 5 (4%) | NS |

MCI, mild cognitive impairment; NS, not significant.
value to predict the potentially reversible group was 23 points (area under the curve 0.80; sensitivity 79.4%, specificity 69.2%; Fig. 1). Table 3 shows the characteristics of participants with MCI in the potentially reversible group (MoCA-J score ≥23) and the potentially irreversible group (MoCA-J score <23), with a significant difference only seen for age.

Multiple logistic regression analysis to predict non-MCI after exercise training showed that MoCA-J score ≥23 (OR 6.9, 95% CI 2.1–22.6; \( P < .001 \)), male sex (OR 3.4, 95% CI 1.0–10.9; \( P = .04 \)) and age (OR 0.9, 95% CI 0.8–1.0; \( P = .04 \)) were independent determinants (Table 4).

**Discussion**

We investigated MoCA-J scores in community-dwelling older adult outpatients before and after a 6-month exercise training program. The present study showed that 65.2% of participants presented cognitive impairment that fulfilled the criteria for MCI (Table 1). This MCI prevalence rate was similar to a previous report in Japanese older community-dwelling residents (64.1%).

In the present study, 46.6% of those in the MCI group reversed to non-MCI after the 6-month exercise training program. Previously, the reversion rate from MCI to non-MCI was reported as 24% with no intervention. The rate of reversion (improvement) to non-MCI after exercise training in the present study was higher than reported in that study. Physical exercise is known to have a positive effect on cognitive function in patients with MCI. Furthermore, multicomponent training has a greater effect on cognitive function than aerobic training alone. Our program included multicomponent exercise training, which might explain the higher rate of reversion to non-MCI after the exercise program than the previous study.

The present study showed that a cut-off score of 23 was optimal to predict cognitive function that was potentially reversible to normal (sensitivity 79.4%, specificity 69.2%). Unlike dementia, MCI is reported to be reversible to normal cognition. A previous study defined MCI as a MoCA score <26. Trzepacz et al. reported that a MoCA cut-off value of ≥17 captured MCI, and <17 captured dementia cases. Based on these previous reports, the present study suggested that a MoCA-J score of 17–22 might reflect irreversible MCI and/or pre-dementia among older adults with MCI (MoCA <26). Therefore, the results of this study show that it is possible to divide people with MCI into two groups: a potentially reversible group (MoCA-J score 23–25) and a potentially irreversible group (MoCA-J score <23).

In addition, multiple logistic regression analysis to predict non-MCI after exercise training among participants with MCI at baseline showed that age, female sex and a MoCA-J cut-off score ≥23 at baseline were independent determinants (Table 4). Previous reports showed that people who reverted from MCI to normal cognition were younger, which is consistent with the results of the present study. However, sex was not previously associated with reversion to normal cognition or progression to dementia, which differs from our findings. These results might differ because the...

---

**Table 2** Changes in mild cognitive impairment prevalence before and after exercise training using \( \chi^2 \) analysis

|                        | Non-MCI | MCI | Total |
|------------------------|---------|-----|-------|
| Before exercise training | Non-MCI | 38 (33.9%) | 1 (0.9%) | 39 |
|                        | (5.4)   | (−5.4) |       |
|                        | MCI     | 34 (30.4%) | 39 (34.8%) | 73 |
|                        | (−5.4)  | (5.4)   |       |
| Total                  |         | 72     | 40    | 112 |

\( P < .001, \varphi = .50 \) [Adjusted standardized residuals.] McNemar test; \( n \) (%). MCI, mild cognitive impairment.

---

**Figure 1** Receiver operating characteristics curve analysis to predict normalized or non-normalized cognitive function after exercise training among participants with mild cognitive impairment. AUC, area under the curve.
The present study was an intervention study rather than an observational study. However, as this study did not include a control group, it was not clear whether there was a sex difference in the improvement of cognitive function by exercise training. In the present study, the MoCA-J cut-off value (≥23) was the most relevant factor in reverting to non-MCI after exercise training. As this study showed that exercise training positively affects cognitive function, exercise interventions should be started as early as possible among those with potentially reversible MCI. Furthermore, the present results might also indicate that treatment with medication therapy is required as early as possible among the potentially irreversible group to prevent progression to Alzheimer’s disease and dementia.

The present study had several limitations. First, this study was the pre-post comparison study and there was no control group. Therefore, we cannot know whether improvement of MCI is due to the effectiveness of the 6-month exercise training program or the learning function by exercise training.

### Table 3
Comparison between potentially reversible and irreversible cognitive function groups using the Japanese version of the Montreal Cognitive Assessment cut-off score of 23

|                | Potentially irreversible group | Potentially reversible group | P-value |
|----------------|--------------------------------|------------------------------|---------|
|                | (n = 39)                        | (n = 34)                     |         |
| Age            | 75.4 ± 5.8                      | 79.4 ± 6.1                   | <0.01   |
| Sex            |                                 |                              |         |
| Male           | 16 (22%)                        | 15 (21%)                     | NS      |
| Female         | 23 (32%)                        | 19 (26%)                     | NS      |
| MoCA-J score   |                                 |                              |         |
| Before         | 24.1 ± 0.7                      | 20.2 ± 2.2                   | <0.001  |
| After          | 26.0 ± 2.5                      | 22.4 ± 3.4                   | <0.001  |
| Changes in MoCA-J score | 1.9 ± 2.4                       | 2.2 ± 2.9                    | NS      |
| Type of illness, n (%) |                              |                              |         |
| Hypertension   | 15 (21%)                        | 11 (15%)                     | NS      |
| Diabetes mellitus | 32 (44%)                      | 30 (41%)                     | NS      |
| Hyperlipidemia | 29 (40%)                        | 21 (29%)                     | NS      |
| Atrial fibrillation | 37 (51%)                  | 29 (40%)                     | NS      |
| Coronary artery disease | 33 (45%)                | 29 (40%)                     | NS      |
| Chronic heart failure | 37 (51%)                | 29 (40%)                     | NS      |
| Cerebral infarction | 35 (48%)                 | 30 (41%)                     | NS      |
| Calcium blocker | 16 (22%)                       | 12 (16%)                     | NS      |
| Medication, n (%) |                              |                              |         |
| Angiotensin converting enzyme inhibitor | 5 (7%)                  | 3 (4%)                       | NS      |
| Angiotensin II receptor blocker | 10 (14%)                | 10 (14%)                     | NS      |
| Beta blocker   | 8 (11%)                         | 13 (18%)                     | NS      |
| Statin         | 8 (11%)                         | 11 (15%)                     | NS      |
| Insulin        | 0 (0%)                          | 0 (0%)                       | NS      |
| Sulfonylureas  | 1 (1%)                          | 0 (0%)                       | NS      |
| Biguanides     | 1 (1%)                          | 1 (1%)                       | NS      |
| Alpha-glucosidase inhibitors | 0 (0%)                | 1 (1%)                       | NS      |
| Dipeptidyl peptidase-4 | 1 (1%)                  | 3 (4%)                       | NS      |
| Prednisolone   | 2 (3%)                          | 1 (1%)                       | NS      |
| Aspirin        | 12 (16%)                        | 10 (14%)                     | NS      |
| Warfarin       | 1 (1%)                          | 4 (5%)                       | NS      |

MoCA-J, Japanese version of the Montreal Cognitive Assessment; NS, not significant.

### Table 4
Multiple logistic regression analysis to predict non-mild cognitive impairment after exercise training among the MCI mild cognitive impairment

|                | B     | Odds ratio (95% CI) | P-value |
|----------------|-------|--------------------|---------|
| MoCA ≥23       | 1.930 | 6.89 (2.11–22.56)   | <0.001  |
| Female         | 1.211 | 3.36 (1.03–10.93)   | 0.04    |
| Age            | −0.106| 0.90 (0.81–1.00)    | 0.04    |

Model $\chi^2 P < 0.001$; Hosmer–Lemeshow $P = .806$; accuracy 74.3%. CI, confidence interval; MCI, mild cognitive impairment; NS, not significant.
effect of the MoCA-J test, or regression to the mean. Second, the sample size in this study was small, especially in terms of male participants.

In conclusion, there is a cut-off MoCA-J score (≥23) that can predict a return to normalized cognitive function with exercise training among community-dwelling older adult outpatients.

Disclosure statement

The authors declare no conflict of interest.

References

1 Nasreddine ZS, Phillips NA, Bedirian V et al. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. *J Am Geriatr Soc* 2005; **53**:695–699.
2 Bruscoli M, Lovestone S. Is MCI really just early dementia? A systematic review of conversion studies. *Int Psychogeriatr* 2004; **16**:129–140.
3 Petersen RCSG, Waring SC, Ivnik RJ, Tangalos EG, Kokmen E. Mild cognitive impairment: clinical characterization and outcome. *Arch Neurol* 1999; **56**:303–308.
4 Shimada H, Makizako H, Doi T, Lee S, Lee S. Conversion and Reversion Rates in Japanese Older People With Mild Cognitive Impairment. *J Am Med Dir Assoc* 2017; **18**:808. e1–808.e6.
5 Grande G, Cucumo V, Cova I et al. Reversible mild cognitive impairment: the role of comorbidities at baseline evaluation. *J Alzheimer’s Dis* 2016; **51**:57–67.
6 Cammisuli DM, Innocenti A, Franzoni F, Pruneti C. Aerobic exercise effects upon cognition in Mild Cognitive Impairment: a systematic review of randomized controlled trials. *Arch Ital Biol* 2017; **155**:54–62.
7 Suzuki T, Shimada H, Makizako H et al. A randomized controlled trial of multicomponent exercise in older adults with mild cognitive impairment. *PLoS ONE* 2013; **8**:e61483.
8 Ohman H, Savikko N, Strandberg TE, Pihlak KH. Effect of physical exercise on cognitive performance in older adults with mild cognitive impairment or dementia: a systematic review. *Dement Geriatr Cogn Disord* 2014; **38**:347–365.
9 Kirk-Sanchez NJ, McGough EL. Physical exercise and cognitive performance in the elderly: current perspectives. *Clin Interv Aging* 2014; **9**:51–62.
10 Tsai KK, Chan JY, Hira H, Wong SY, Kwok TC. Cognitive tests to detect dementia: a systematic review and meta-analysis. *JAMA Intern Med* 2015; **175**:1450–1458.
11 Fujiwara Y, Suzuki H, Yasunaga M et al. Brief screening tool for mild cognitive impairment in older Japanese: validation of the Japanese version of the Montreal Cognitive Assessment. *Geriatr Gerontol Int* 2010; **10**:225–232.
12 Reiter K, Nielson KA, Smith TJ, Weiss LR, Alfini AJ, Smith JC. Improved cardiorespiratory fitness is associated with increased cortical thickness in mild cognitive impairment. *J Int Neuropsychol Soc* 2015; **21**:757–767.
13 Fujiwara Y, Suzuki H, Kawai H et al. Physical and sociopsychological characteristics of older community residents with mild cognitive impairment as assessed by the Japanese version of the Montreal Cognitive Assessment. *J Geriatr Psychiatry Neurol* 2013; **26**:209–220.
14 Smith PJ, Blumenthal JA, Hoffman BM et al. Aerobic exercise and neurocognitive performance: a meta-analytic review of randomized controlled trials. *Psychosom Med* 2010; **72**:239–252.
15 Trzepacz PT, Hochstetler H, Wang S, Walker B, Saykin AJ. Relationship between the Montreal Cognitive Assessment and Mini-mental State Examination for assessment of mild cognitive impairment in older adults. *BMC Geriatr* 2015; **15**:107.
16 Olazaran J, Torrero P, Cruz I et al. Mild cognitive impairment and dementia in primary care: the value of medical history. *Fam Pract* 2011; **28**:385–392.
17 Inzelberg R, Massarwa M, Schechtman E, Strugatsky R, Farrer LA, Friedland RP. Estimating the risk for conversion from mild cognitive impairment to Alzheimer’s disease in an elderly Arab community. *J Alzheimers Dis* 2015; **45**:865–871.