Association of Postural Instability With Asymptomatic Cerebrovascular Damage and Cognitive Decline

The Japan Shimanami Health Promoting Program Study

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Background and Purpose—Asymptomatic cerebral small-vessel disease (cSVD) in elderly individuals are potent risk factors for stroke. In addition to common clinical risk factors, postural instability has been postulated to be associated with cSVD in older frail patients. Here, we conducted a cross-sectional study to understand the possible link between postural instability and asymptomatic cSVD further, namely periventricular hyperintensity, lacunar infarction, and microbleeds, as well as cognitive function, in a middle-aged to elderly general population (n=1387).

Methods—Postural instability was assessed based on one-leg standing time (OLST) and posturography findings. cSVD was evaluated by brain MRI. Mild cognitive impairment was assessed using a computer-based questionnaire, and carotid intima-media thickness as an index of atherosclerosis was measured via ultrasonography.

Results—Frequency of short OLST, in particular <20 s, increased linearly with severity of cSVD (lacunar infarction lesion: none, 9.7%; 1, 16.0%; >2, 34.5%; microbleeds lesion: none, 10.1%; 1, 15.3%; >2, 30.0%; periventricular hyperintensity grade: 0, 5.7%; 1, 11.5%; >2, 23.7%). The association of short OLST with lacunar infarction and microbleeds but not periventricular hyperintensity remained significant even after adjustment for possible covariates (lacunar infarction, P=0.009; microbleeds, P=0.003; periventricular hyperintensity, P=0.601). In contrast, no significant association was found between posturographic parameters and cSVD, whereas these parameters were linearly associated with OLST. Short OLST was also significantly associated with reduced cognitive function independent of covariates, including cSVD (P=0.002).

Conclusions—Postural instability was found to be associated with early pathological changes in the brain and functional decline, even in apparently healthy subjects.

Key Word: stroke, lacunar
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Assessment of Postural Instability

One-leg standing time (OLST) with eyes open was used as an index of postural stability, with the leg selected by the subject. Time interval until the raised leg was put down was measured twice, with a maximum time of 60 s allowed. The better of the 2× was used for statistical analysis.

Postural instability was also measured using a posturograph (Gravicorder G-5500; Anima Inc, Tokyo, Japan) consisting of an equilateral triangular footplate with 3 built-in vertical force transducers to determine instantaneous fluctuations in the center of pressure. Signals were processed by a DC amplifier and low-pass filters (cutoff frequency 10 Hz) and stored in a computer after analog-digital conversion at a sampling rate of 20 Hz. Subjects were instructed to maintain a static upright posture on the footplate with their feet together while watching a circular achromatic target placed 200 cm ahead of their eye point. Data were acquired for 1 minute, beginning after the subject’s posture had stabilized. The subject then rested for 1 minute while seated, after which the measurement was repeated with the eyes closed to assess the effects of visual feedback on postural stability.

All measurements were performed barefoot with both arms held at the side of the body. Path length and circumferential area of the center of pressure movement were considered parameters for movement of center of gravity and used as indices of postural stability.

MRI and Assessment of Silent Cerebral Damage

The presence of cSVDs, including lacunar infarctions, PVH, and microbleeds, was evaluated based on findings on brain MRI with a 3-tesla scanner (Signa Excite 3.0T; GE Healthcare, Milwaukee, WI). MRI was performed within 1 month before the clinical measurements (mean, 19±10 days). The following images parallel to the orbitomeatal line were obtained: T1-weighted axial images (repetition time, 2000.0 ms; echo time, 16.0 ms; thickness, 6.0 mm; gap, 1.0 mm; matrix, 288×224), T2-weighted axial images (repetition time, 4800.0 ms; echo time, 92.0 ms; thickness, 6.0 mm; gap, 1.0 mm; matrix, 512×256), fluid-attenuated inversion recovery images (repetition time, 11000.0 ms; echo time, 140.0 ms; thickness, 6.0 mm; gap, 1.0 mm; matrix, 288×224), and gradient-echo (T2*-weighted) images (repetition time, 600.0 ms; echo time, 7.2 ms; thickness, 6.0 mm; gap, 1.0 mm; matrix, 320×192).

Lacunar infarction was defined as areas of low signal intensity (3- to 15-mm diameter) on T1-weighted images and of high intensity on T2-weighted and fluid-attenuated inversion recovery images. Microbleeds were defined as small (2- to 5-mm diameter) hypointense lesions on T2*-weighted images. Such lesions within the subarachnoid space and areas of symmetrical hypointensity in the globus pallidus on T2*-weighted images were considered likely to represent adjacent pial blood vessels and calcifications, respectively, and were therefore ignored. PVH were defined as white matter hyperintensities depicted on T2-weighted and fluid-attenuated inversion recovery images in contact with the ventricular wall. PVH was further classified into 5 grades according to a scale developed by Shinohara et al and later modified and published as a guideline by the Japan Brain Dock Society, as follows: grade 0, absent or only a rim; grade 1, limited lesion-like caps; grade 2, irregular halo; grade 3, irregular margins and extension into the deep white matter; and grade 4, extension into the deep white matter and subcortical portion. PVH grade ≥2 was considered a pathological condition according to the guideline, as well as based on our previous findings indicating a greater frequency of left ventricular hypertrophy and microbleeds in subjects showing PVH grade ≥2 than in those with lower scores. Imaging analysis was performed by neurologists without clinical information on the subject. Images were analyzed using Osirix software (http://www.osirix-viewer.com).

Assessment of Mild Cognitive Impairment

Mild cognitive impairment was assessed using a Touch Panel-type Dementia Assessment Scale (TDAS), which was specifically designed to rate cognitive dysfunction quickly and without the need for a special rater. This test battery consists of the following 4 tasks, which were performed in a fixed order: a 3-word memory test for assessing immediate memory, temporal orientation test, 3-dimensional visual-spatial perception test, and delayed recall test for assessing short-term memory. The TDAS provides for a maximum score of 15 points, and a score of 13 was suggested as a cutoff point in discriminating cognitive impairment in a previous study. Details of this rating system have been described elsewhere.

Arterial Parameters

We measured carotid intima-media thickness (IMT) as an index of arteriosclerosis. To measure IMT, ultrasonography of the common carotid artery was performed using an SSD-3500SV or c10 ultrasonograph (Aloka Co, Ltd, Tokyo, Japan) with a 7.5-MHz probe. After 5-minute resting in the supine position, optical visualization of the bilateral carotid arteries was obtained with the subject’s head tilted slightly upward in the midline position. IMT of the far wall was measured from B-mode imaging onboard software, which simultaneously measured IMT at 3 points at 1-cm intervals. Nine IMTs of the far wall were measured at 1-cm intervals proximal to the bulb from the anterior, lateral, and posterior approaches. Mean

Methods

Study Subjects

The study subjects were 1387 apparently healthy middle-aged to elderly individuals who were consecutive participants in the medical checkup program at Ehime University Hospital Anti-aging Center from February 2006 to June 2013. This medical checkup is provided to general residents of Ehime Prefecture, Japan, and is specifically designed to evaluate aging-related disorders, including atherosclerosis, cardiovascular disease, physical function, and mild cognitive impairment. A full list of clinical parameters measured in the medical checkup program is presented in Table I in the online-only Data Supplement. Evaluation of diagnostic and prognostic significance of postural instability was an initially planned study theme. Here, we conducted a cross-sectional study to understand the possible link between postural instability and asymptomatic cSVDs further—namely, PVH, lacunar infarction, and microbleeds—in a middle-aged to elderly general population. As we previously showed that individuals with mild cognitive impairment, particularly those with Alzheimer disease, were prone to instability while standing on 1 leg, we attempted to gather more evidence in the present study.

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IMT calculated from the 9 readings was used in the analysis. No measurements were taken at the discrete plaque level.

### Basic Clinical Parameters

Basic clinical parameters used in this study were measured through the medical checkup program. Brachial blood pressure was measured after 5-minute resting in the sitting position (HEM-9000AI; Omron Healthcare, Kyoto, Japan). Hypertension was defined as either or both systolic blood pressure ≥140 mm Hg or diastolic BP ≥90 mm Hg, or taking antihypertensive drugs. Type 2 diabetes mellitus was defined as any or all of the following: plasma glucose ≥126 mg/dL, glycohemoglobin A1c ≥6.5%, or taking antihyperglycemic drugs.

### Statistical Analysis

Differences in numeric variables were assessed by ANOVA, whereas frequency difference was assessed by a χ² test. Covariate adjusted analysis was performed by linear regression analysis. Factors independently associated with number or grade of cSVDs were assessed by a Poisson regression analysis, whereas a Tobit model with Weibull distribution was used in the multivariate analysis for OLST. Statistical analyses were conducted using commercially available statistical software (JMP version 9.0.2; SAS Institute Inc, Cary, NC) or the free R software (R version 3.0.2; http://www.r-project.org), with P<0.05 considered statistically significant.

### Results

Clinical characteristics of the study subjects are shown in Table 1. Differences in the clinical parameters by the presence of cSVD are summarized in Table 2. Subjects with any cSVD tended to be older, more frequently hypertensive, and had higher carotid IMT than those without.

Frequency of short OLST, particularly OLST<20 s, increased linearly with number of lacunar infarctions (P<0.001), number of microbleeds (P=0.023), and PVH grade (P<0.001; Figure 1). Therefore, we used OLST 20 s as a cutoff point. Although several clinical parameters differ based on the presence of cSVD (Table 2), the associations of short OLST with lacunar infarction and microbleeds but not PVH remain significant even after adjustment for the covariates (Table 3). These associations were also found in a subanalysis with elderly subjects (≥65 years; lacunar infarction, P=0.007; microbleeds, P=0.021; PVH, P=0.653). However, conversely, existence of cSVD was not identified as an independent determinant for OLST (lacunar infarction, P=0.717; microbleeds, P=0.737; PVH, P=0.347) on Tobit regression analysis adjusted for age, sex, body mass index, current smoking, neuropsychiatric medication, hypotension, type 2 diabetes mellitus, and carotid IMT. Age and body mass index were identified as major determinants for OLST (P<0.001).

A significant linear correlation was noted between OLST and posturographic parameters for center of gravity movement (Table 4). However, although the posturographic parameters differed significantly based on the presence of cSVD in crude analysis, these associations disappeared in the covariates-adjusted analysis (Table 4).

Association between OLST and cognitive function is illustrated in Figure 2. Short OLST was significantly associated with lower TDAS score (Figure 2) and vice versa (ie, individuals with TDAS score <13 points had significantly shorter mean OLST than subjects with higher scores; 44.9±20.9 versus 52.4±15.9 s; P<0.001 [Tobit regression analysis]). Although subjects with cSVD had significantly lower TDAS scores overall (lacunar infarction, 14.0±1.5 versus 14.2±1.0; P=0.007; microbleeds, 14.0±1.4 versus 14.2±1.1; P=0.038; and PVH, 13.9±1.4 versus 14.3±1.0; P<0.001), the association of short OLST with TDAS score was independent of possible covariates, including cSVD (Figure 2). We included lacunar infarction, microbleeds, and PVH in a same regression model. However, no severe collinearity was detected among these factors (variation inflation factor: lacunar infarction; cSVDs, cerebral small-vessel disease; DBP, diastolic blood pressure; HbA1c, glycohemoglobin A1c; IMT, intima-media thickness; OLST, one-leg standing time; PB, peripheral hyperintensity; and SBP, systolic blood pressure).

### Table 1. Clinical Characteristics of Study Subjects (n=1387)

<table>
<thead>
<tr>
<th>Age, y</th>
<th>67±8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (men/women)</td>
<td>546/841</td>
</tr>
<tr>
<td>Body height, cm</td>
<td>157.3±8.4</td>
</tr>
<tr>
<td>Body weight, kg</td>
<td>57.8±10.2</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>23.2±3.1</td>
</tr>
<tr>
<td>Smoking (current, %)</td>
<td>5.8</td>
</tr>
<tr>
<td>Medication, %</td>
<td></td>
</tr>
<tr>
<td>Antihypertensive drugs</td>
<td>30.4</td>
</tr>
<tr>
<td>Antihyperglycemic drugs</td>
<td>6.1</td>
</tr>
<tr>
<td>Neuropsychiatric drugs</td>
<td>11.9</td>
</tr>
<tr>
<td>SBP, mm Hg</td>
<td>136±19</td>
</tr>
<tr>
<td>DBP, mm Hg</td>
<td>77±11</td>
</tr>
<tr>
<td>Hypertension, %</td>
<td>53.7</td>
</tr>
<tr>
<td>Glucose, mg/dL</td>
<td>104±19</td>
</tr>
<tr>
<td>HbA1c, %</td>
<td>5.9±0.6</td>
</tr>
<tr>
<td>Type 2 diabetes mellitus, %</td>
<td>14.0</td>
</tr>
<tr>
<td>Carotid IMT, mm</td>
<td>0.79±0.14</td>
</tr>
<tr>
<td>OLST, n</td>
<td></td>
</tr>
<tr>
<td>≤60, s</td>
<td>1030</td>
</tr>
<tr>
<td>&lt;60, s</td>
<td>89</td>
</tr>
<tr>
<td>&lt;40, s</td>
<td>120</td>
</tr>
<tr>
<td>&lt;20, s</td>
<td>148</td>
</tr>
<tr>
<td>Posturography</td>
<td></td>
</tr>
<tr>
<td>Eyes open</td>
<td></td>
</tr>
<tr>
<td>Path length, cm</td>
<td>89±31</td>
</tr>
<tr>
<td>Circumferential area, cm²</td>
<td>3.39±1.94</td>
</tr>
<tr>
<td>Eyes closed</td>
<td></td>
</tr>
<tr>
<td>Path length, cm</td>
<td>144±72</td>
</tr>
<tr>
<td>Circumferential area, cm²</td>
<td>5.73±4.21</td>
</tr>
<tr>
<td>Lacunar infarction (n=0/1/2/&gt;3)</td>
<td>1264/94/20/9</td>
</tr>
<tr>
<td>PVH (grade=0/1/2/3/4)</td>
<td>574/636/156/18/3</td>
</tr>
<tr>
<td>Microbleeds (n=0/1/2/&gt;3)</td>
<td>1295/72/12/8</td>
</tr>
</tbody>
</table>

Values are mean±SD. Hypertension was defined as SBP ≥140 mm Hg or DBP ≥90 mm Hg, or taking antihypertensive drugs. Type 2 diabetes mellitus was defined as any or all of the following: plasma glucose ≥126 mg/dL, HbA1c ≥6.5%, and taking antihyperglycemic drugs. Neuropsychiatric drugs include hypnotics, analgesics, anxiolytic drugs, and antidepressants. BMI indicates body mass index; cSVDs, cerebral small-vessel disease; DBP, diastolic blood pressure; HbA1c, glycohemoglobin A1c; IMT, intima-media thickness; OLST, one-leg standing time; PB, peripheral hyperintensity; and SBP, systolic blood pressure.
Discussion

In the present study, we showed that short OLST (<20 s) but not posturographic parameters for center of gravity movement was significantly associated with cSVDs in an apparently healthy general population of middle-aged to elderly individuals. To our knowledge, this is the first study reporting the independent association of OLST with lacunar infarction and microbleeds, with the previously reported possible association of OLST with PVH not observed in our data set. Short OLST was also independently associated with impaired cognitive function.

The relationship between postural instability and PVH has been investigated in several studies, with results consistently supporting the positive relationship between the 2 parameters; however, few studies have been concluded on lacunar infarction, and even fewer on microbleeds. One strength of our present study was, therefore, the concomitant evaluation of cSVDs and findings of a positive association of postural instability with lacunar infarction and microbleeds. We also evaluated cognitive function and found a cSVD-independent association of postural instability with cognitive decline. Elucidation of postural instability as a factor for not only brain histological change but also functional decline was another strength of our study.

No significant association was found between postural instability and PVH, even in the subanalysis in elderly subjects although several previous studies have reported greater severity of PVH in subjects with short OLST or low physical function. Although reasons for the discrepancy are unclear, our results suggest that postural instability might not always be associated with PVH. Subtypes of first-ever stroke observed in both hospital-based or community-based longitudinal studies

Table 2. Differences in Clinical Parameters Based on the Presence of cSVD

<table>
<thead>
<tr>
<th></th>
<th>Lacunar Infarction</th>
<th>Microbleeds</th>
<th>PVH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>cSVD Mean±SD</td>
<td>P Value</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, y</td>
<td>+ 70±7 &lt;0.001*</td>
<td>70±7 &lt;0.001*</td>
<td>73±6 &lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>− 66±8</td>
<td>66±8</td>
<td>66±7</td>
</tr>
<tr>
<td>Sex (male %)</td>
<td>+ 46.3 0.097</td>
<td>44.6 0.291</td>
<td>41.2 0.584</td>
</tr>
<tr>
<td></td>
<td>− 38.7</td>
<td>39.0</td>
<td>39.1</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>+ 23.6±3.2 0.179</td>
<td>23.3±3.1 0.720</td>
<td>23.3±3.1 0.922</td>
</tr>
<tr>
<td></td>
<td>− 23.2±3.0</td>
<td>23.2±3.1</td>
<td>23.2±3.0</td>
</tr>
<tr>
<td>Neurepsychiatric drugs, %</td>
<td>+ 15.5 0.204</td>
<td>13.0 0.727</td>
<td>19.9 0.001*</td>
</tr>
<tr>
<td></td>
<td>− 11.6</td>
<td>11.8</td>
<td>10.7</td>
</tr>
<tr>
<td>Hypertension, %</td>
<td>+ 74.8 &lt;0.001*</td>
<td>79.4 &lt;0.001*</td>
<td>67.8 &lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>− 51.7</td>
<td>51.9</td>
<td>51.7</td>
</tr>
<tr>
<td>Type 2 diabetes mellitus, %</td>
<td>+ 18.7 0.115</td>
<td>21.7 0.027*</td>
<td>18.6 0.056</td>
</tr>
<tr>
<td></td>
<td>− 13.5</td>
<td>13.4</td>
<td>13.3</td>
</tr>
<tr>
<td>Carotid IMT, mm</td>
<td>+ 0.84±0.13 &lt;0.001*</td>
<td>0.84±0.14 0.004*</td>
<td>0.84±0.17 &lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>− 0.79±0.14</td>
<td>0.79±0.14</td>
<td>0.79±0.14</td>
</tr>
</tbody>
</table>

Values are mean±SD or frequency. Differences in numeric variables were assessed by ANOVA, whereas frequency difference was assessed by a $\chi^2$ test. cSVD was defined as presence of lacunar infarction, microbleeds, and PVH grade ≥2. BMI indicates body mass index; cSVD, cerebral small-vessel disease; IMT, intima-media thickness; and PVH, periventricular hyperintensity.

*Statistical significance.

Figure 1. A–C. Association between cerebral small-vessel diseases and one-leg standing time (OLST). Number of each subgroup is shown in parentheses.
are known to differ significantly between Japanese population and whites in Western countries, with the Japanese proving more prone to hemorrhage stroke. Furthermore, the proportion of lacunar stroke to total ischemic stroke in Japan was higher than that reported in Western countries. Given these previous epidemiological data, some ethnic differences might be involved in the differences in relationships of physiological instability and PVH between our study population and whites.

Table 3. Poisson Regression Analysis for Cerebral Small-Vessel Disease

<table>
<thead>
<tr>
<th></th>
<th>No. of Lacunar Infarction</th>
<th>No. of Microbleeds</th>
<th>PVH Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>P Value</td>
<td>Coefficient</td>
</tr>
<tr>
<td>Age, y</td>
<td>0.036</td>
<td>0.041*</td>
<td>0.027</td>
</tr>
<tr>
<td>Sex (male)</td>
<td>0.013</td>
<td>0.876</td>
<td>0.014</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>−0.011</td>
<td>0.675</td>
<td>−0.024</td>
</tr>
<tr>
<td>Current smoking</td>
<td>0.443</td>
<td>0.001*</td>
<td>0.203</td>
</tr>
<tr>
<td>Neuropsychiatric medication</td>
<td>−0.004</td>
<td>0.969</td>
<td>−0.248</td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.321</td>
<td>&lt;0.001*</td>
<td>0.716</td>
</tr>
<tr>
<td>Type 2 diabetes mellitus</td>
<td>0.019</td>
<td>0.858</td>
<td>0.021</td>
</tr>
<tr>
<td>Carotid IMT, mm</td>
<td>0.686</td>
<td>0.224</td>
<td>0.763</td>
</tr>
<tr>
<td>OLST (&lt;20 s)</td>
<td>0.260</td>
<td>0.015*</td>
<td>0.334</td>
</tr>
</tbody>
</table>

BMI indicates body mass index; IMT, intima-media thickness; OLST, one-leg standing time; and PVH, periventricular hyperintensity.

Table 4. Associations Between cSVD and Posturographic Parameters

<table>
<thead>
<tr>
<th></th>
<th>Path Length, cm</th>
<th>Circumference Area, cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>cSVD</td>
<td>Path Length, cm</td>
</tr>
<tr>
<td></td>
<td>Mean±SD</td>
<td>Crude Adjusted</td>
</tr>
<tr>
<td>Eyes open</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OLST, s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>83±25</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>&lt;60</td>
<td>102±30</td>
<td>3.75±1.86</td>
</tr>
<tr>
<td>&lt;40</td>
<td>102±33</td>
<td>4.71±3.56</td>
</tr>
<tr>
<td>&lt;20</td>
<td>115±46</td>
<td>3.61±1.92</td>
</tr>
<tr>
<td>Lacunar infarction +</td>
<td>99±33</td>
<td>3.70±2.11</td>
</tr>
<tr>
<td>−</td>
<td>89±31</td>
<td>3.70±2.11</td>
</tr>
<tr>
<td>Microbleeds +</td>
<td>95±33</td>
<td>3.66±1.92</td>
</tr>
<tr>
<td>−</td>
<td>89±31</td>
<td>3.66±1.92</td>
</tr>
<tr>
<td>PVH +</td>
<td>100±33</td>
<td>3.07±3.27</td>
</tr>
<tr>
<td>−</td>
<td>88±31</td>
<td>3.29±1.64</td>
</tr>
<tr>
<td>Eyes closed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OLST, s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>131±56</td>
<td>4.97±2.98</td>
</tr>
<tr>
<td>&lt;60</td>
<td>172±82</td>
<td>7.62±6.32</td>
</tr>
<tr>
<td>&lt;40</td>
<td>172±108</td>
<td>8.62±6.32</td>
</tr>
<tr>
<td>&lt;20</td>
<td>186±100</td>
<td>6.52±4.65</td>
</tr>
<tr>
<td>Lacunar infarction +</td>
<td>161±87</td>
<td>3.68±4.72</td>
</tr>
<tr>
<td>−</td>
<td>142±71</td>
<td>5.62±4.65</td>
</tr>
<tr>
<td>Microbleeds +</td>
<td>153±75</td>
<td>5.62±4.65</td>
</tr>
<tr>
<td>−</td>
<td>143±72</td>
<td>5.62±4.65</td>
</tr>
<tr>
<td>PVH +</td>
<td>164±84</td>
<td>6.80±5.43</td>
</tr>
<tr>
<td>−</td>
<td>141±70</td>
<td>6.80±5.43</td>
</tr>
</tbody>
</table>

Values are mean±SD. Adjusted factors were age, sex, body mass index, current smoking, neuropsychiatric medication, hypertension, type 2 diabetes mellitus, and carotid intima-media thickness. Small-vessel disease was defined as presence of lacunar infarction, microbleeds, and PVH grade ≥2. cSVD indicates cerebral small-vessel disease; OLST, one-leg standing time; and PVH, periventricular hyperintensity. *Statistical significance.
the relevance of gait dysfunction to brain abnormalities further
infarction. Because gait consists of 3 primary components
as same in a previous study, marked shortening of OLST
with dementia.
a factor involved in the elevated incidence of falls in subjects
perception, and the ability to recognize and avoid hazards.
likely by impairing judgment, motor function, visual-spatial
(balance, locomotion, and adaptation to the environment),
falls and fall-related bone fractures in elderly subjects,
to the well-known risk factors, dementia increases risk of
cSVD. Previous studies have suggested that, in addition
OLST and cognitive decline was independent of the existence
a relatively low TDAS score, the association between short
OLST might not be independently associated with OLST.
Marked cognitive decline was observed in subjects with
short OLST. Although cSVDs was naturally associated with
a relatively low TDAS score, the association between short
OLST and cognitive decline was independent of the existence
of cSVD. Previous studies have suggested that, in addition
to the well-known risk factors, dementia increases risk of
falls and fall-related bone fractures in elderly subjects,
likely by impairing judgment, motor function, visual-spatial
perception, and the ability to recognize and avoid hazards.
Given the present findings, postural instability might also be
a factor involved in the elevated incidence of falls in subjects
with dementia.
OLST was strongly and inversely associated with age;
as same in a previous study, marked shortening of OLST
occurred in subjects aged ≥60 years; it was also strongly
and age-independently associated with increasing center of
gravity movement; however, no significant correlation was
observed between posturographic parameters and cSVD. As
posturographic measurements were performed with subjects
in a static upright posture, greater difficulty of postural con-
control in one-leg standing than in an upright position with feet
gether might be a reason for the relevance of short OLST, but
not high posturographic parameters, to cSVD. Previous stud-
ies reported that gait dysfunction was a physical marker that
was associated with brain white matter lesions and small
infarction. Because gait consists of 3 primary components
(balance, locomotion, and adaptation to the environment),
the relevance of gait dysfunction to brain abnormalities further
supports the importance of balance-function as a physical fac-
tor for cSVD.
Several limitations to the present study warrant mention.
First, we measured postural instability using a posturogra-
for 60 s. Previous studies have suggested that 3 trials of 120-s
measurements are needed to obtain reliable results; as such,
our findings for OLST may lead to underestimation. Second,
we measure neither physical functions, such as gait speed or
gait abnormality, nor history or incident of falls. These data
would help further clarify the relationship between physical
function and brain abnormalities, including impaired cog-
nitive function. Third, the present study is a cross-sectional
design. Additional longitudinal studies are, therefore, required
to clarify the prognostic significance of postural instability.

Summary
Our data from community-dwelling residents identifies pos-
tural instability as a factor in early pathological changes in
the brain and functional decline, even in apparently healthy sub-
jects. In older individuals, comprehensive geriatric assessment
of frailty has been reported useful in increasing hospitalized
patient’s survival duration. Furthermore, complex interven-
tion was reported to be useful in helping community-dwelling
elderly people to live independently. Comprehensive geri-
atriac assessment is usually defined as a multidimensional
diagnostic process focused on determining medical, psychol-
ological, and functional capability of a frail older patient.
Our findings incorporates postural instability as an important
measure of comprehensive geriatric assessment, and individu-
als showing postural instability should subsequently receive
increased attention because this instability may signal poten-
tial brain abnormalities and cognitive decline.

Acknowledgments
We thank Yoko Ochi and Hideka Fuyuki for their help in collecting
clinical data.

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Disclosures
None.

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Abstract

Association of Postural Instability With Asymptomatic Cerebrovascular Damage and Cognitive Decline
The Japan Shimamami Health Promoting Program Study

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제위불안정과 무중상 뇌혈관 손상 및 인지 기능 저하 사이의 관련성

배경과 목적
노인에서 발견되는 무중상 뇌 소혈관 질환(cerebral small-vessel disease, cSVD)은 뇌졸중의 강력한 위험 인자이다. 일반적으로 알려진 임상적 위험 인자와 함께, 제위불안정은 고령의 좌약한 노인에서 cSVD와 관련되어 있을 것이라는 가설이 제안된 바 있다. 본 연구에서는 증상 및 환자 연령층의 일반인(n=1387)을 대상으로 하여, 제위불안정과 무중상 cSVD(뇌실주위 고신호 강도, 열공성 뇌경색 및 미세 출혈) 및 인지 기능 사이의 잠재적인 연관 관리를 위한 단편 연구를 수행하였다.

방법
제위불안정의 일측 적립 시간(one-leg standing time, OLST) 및 제위기록(posturography) 결과로 측정하였다. cSVD는 뇌 자기공명영상으로 평가하였다. 경도 인지장애는 컴퓨터에 기반한 시각적 인지성능검사로 진단하였다. 비정상적 내막막두께(intima-media thickness)는 초음파검사로 측정하였으며, 측정부위중심의 자료로 간주하였다.

결과
특히 20초 미만의 짧은 OLST 빈도는 cSVD 증증도와 직선적인 상관 관계를 보였다(평균 OLST 시간: 20초, 22초, 24초; 각각 30.0%, 60.0%, 90.0% 사이). cSVD의 수준은 OLST가 짧을수록 높아졌으며, OLST가 짧을수록 cSVD의 수준이 높아졌다. 

결론
제위불안정은 건강한 사람에서도 뇌의 초기 병리학적 변화 및 기능적 감소와 연관성을 보인다.