Postural sway velocity predicts osteoporotic fracture in community-dwelling elderly Japanese women: the Muramatsu Study

SIR—Impaired balance is an independent risk factor for falls. Studies have shown that tests of postural sway identify elderly people who recurrently fall [1–4]. Thapa et al. [2] demonstrated that falls are more frequent with increasing postural sway in ambulatory nursing home residents. Furthermore, Melzer et al. [3] proved higher measures of postural sway in fallers than non-fallers in community-dwelling elderly populations. In contrast, less evidence exists on whether a test of postural sway can usefully predict fractures in the elderly. Some epidemiologic studies have addressed this issue [5–7]; however, these studies either did not conduct sufficient statistical adjustment for potential confounders or did not evaluate postural sway velocity in a precise manner. For these reasons, more evidence is needed to establish such an association. This study aimed to clarify the association between postural sway and incident fractures in community-dwelling elderly women.

Subjects and methods

Participants

A total of 769 women aged 69 years and over, living in Muramatsu, Japan, participated in this study. All participants were ambulatory and non-institutionalised. Of the 769 subjects, 767 were followed for up to 6 years and comprised the Muramatsu cohort. Written informed consent was obtained from all subjects. This study was approved by the Ethics Committee of Niigata University School of Medicine.

Measurements

The baseline study, conducted between May and June 2003, included assessment of postural sway, bone mineral density (BMD), biochemical measurements and an interview. Standing postural sway was evaluated by measuring gravity-centre sway. Subjects stood in the Romberg position [8] on a gravicorder (GS-10, Anima, Inc., Tokyo, Japan) [9]. Subjects stood for 30 s while looking at a round mark (3 cm in diameter) placed 2 m in front of their eyes. Researchers ensured that the subjects looked at the mark during all measurements. The velocity of locus of gravity-centre sway (postural sway) was recorded. Grip strength was measured with a digital hand dynamometer (T.K. 5401, Takei Scientific Instruments Co., Ltd, Niigata, Japan), once each for both hands, and an average value was calculated. Body mass index (BMI) was calculated by

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weight (kg) divided by the square of height (m). Forearm BMD in the non-dominant arm was measured by dual-energy X-ray absorptiometry using a DTX-200 Osteometer. A non-fasting blood specimen was drawn for biochemical analysis, and serum 25-hydroxyvitamin D (25 [OH]D) concentration, an index of vitamin D nutritional status, was measured. Calcium intake was estimated with a validated semi-quantitative food frequency questionnaire [10]. Demographic and other medical data were obtained through a clinical interview. Physical activity levels were assessed by level of engagement in: (i) light exercise, such as croquet or strolls, and (ii) moderate physical activity, such as farm work or gardening. Details of the baseline examination in the Muramatsu cohort study have been published previously [10].

Fracture ascertainment

The incidence of new fractures was assessed every year after the baseline evaluation. In 2009, cumulative fractures occurring over the prior 6 years were confirmed via interview, mail or telephone. Reported fractures were confirmed by orthopaedist review of diagnostic X-ray films. Symptomatic vertebral fractures in the lumbar or thoracic region were diagnosed using criteria of the Japanese Society for Bone and Mineral Research [11]. This study primarily considered limb and vertebral fractures as osteoporotic fractures. Fractures due to high-energy trauma, such as motor vehicle accidents, were excluded from this study.

Statistical procedures

The Cox proportional hazards model was used to calculate the hazard ratio (HR) of fracture for a quartile group versus the reference group of postural sway velocity. HRs were adjusted for age, BMI, BMD, serum 25(OH)D (1, <71 nmol/l, 0, ≥71 nmol/l), calcium intake, concurrent treatment for osteoporosis and engagement in light or moderate physical activity. Categorisation of serum 25(OH) D was based on our previous analysis [12]. The population-attributable fraction (PAF) (%) was estimated as pd × (HR – 1)/HR, where pd is the proportion of cases exposed to the risk factors [13]. SAS software (release 9.13, SAS Institute Inc., Cary, NC, USA) was used for statistical analysis. A P-value of <0.05 was considered significant.

Results

Subject characteristics at baseline stratified by fracture status are shown in Table 1. There was a significant difference between the two groups in the forearm BMD and serum 25(OH)D concentrations.

Fifty-one limb and vertebral fractures occurred in 50 cases during the follow-up period, including 19 in the forearm, 8 in the upper arm, 7 in the upper leg (including 6 hip fractures), 3 in the lower leg and 14 in the vertebra (lumbar or thoracic region). In one case, a subject sustained both limb and vertebral fractures simultaneously. Sixteen fractures occurred at other sites, including three in the hand, eight in the ribs, one in the coccyx, one in the patella and three in the foot. In total, 67 fractures occurred in the 66 cases.

HRs of fracture according to quartiles (Q) of postural sway velocity are shown in Table 2. The unadjusted and adjusted HRs of limb or vertebral fracture in Q4 of postural sway velocity (≥2.5 cm/s) was significantly higher than those in Q1 (<1.5 cm/s). The pooled adjusted HR was 2.27 (95% CI: 1.27–4.06) in Q4 versus Q1–3 combined. Cumulative incidence of limb and vertebral fractures using the Kaplan–Meier method stratified by postural sway status is illustrated in Appendix 1 (Supplementary data available in Age and Ageing online). The PAF of limb or vertebral fracture relative to Q1–3 combined (an unexposed group) was 23.4% (pd = 0.42 and HR = 2.26 for Q4 as an exposed group).

When limb fractures or all fractures were considered as an outcome variable, results were similar to that of limb or vertebral fracture, although HRs in Q4 were not significantly higher than in Q1. The pooled adjusted HR of limb fractures and all fractures in Q4 versus Q1–3 combined was 2.02 (95% CI: 1.03–3.98) and 1.89 (95% CI: 1.12–3.17), respectively. Grip strength was not associated with incident fracture across all Q. Profiles of other risk factors in relation to the fracture incidence have been reported elsewhere [12].

Discussion

The present study demonstrated that postural sway is a predictor of osteoporotic fracture, independent of age,
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Table 2. HRs of fracture according to Q of postural sway velocity

<table>
<thead>
<tr>
<th>Postural sway velocity (cm/s)</th>
<th>Q1 [1.5]</th>
<th>Q2 [1.5, &lt;1.9]</th>
<th>Q3 [1.9, &lt;2.5]</th>
<th>Q4 [≥2.5]</th>
<th>P for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Limb or vertebral fracture</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of cases</td>
<td>9</td>
<td>10</td>
<td>10</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Person-years (P-Y)</td>
<td>1114</td>
<td>1040</td>
<td>1102</td>
<td>993</td>
<td></td>
</tr>
<tr>
<td>Incidence (/1,000 P-Y)</td>
<td>8.1</td>
<td>9.6</td>
<td>9.1</td>
<td>21.1</td>
<td></td>
</tr>
<tr>
<td>Unadjusted HR (95% CI)</td>
<td>1 (reference)</td>
<td>1.20 (0.49–2.94)</td>
<td>1.13 (0.46–2.77)</td>
<td>2.64 (1.21–5.76)</td>
<td>0.0128</td>
</tr>
<tr>
<td>Adjusted* HR (95% CI)</td>
<td>1 (reference)</td>
<td>1.39 (0.54–3.55)</td>
<td>1.10 (0.44–2.75)</td>
<td>2.26 (1.00–5.12)</td>
<td>0.0211</td>
</tr>
<tr>
<td><strong>Limb fracture</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of cases</td>
<td>7</td>
<td>8</td>
<td>7</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Person-years (P-Y)</td>
<td>1119</td>
<td>1043</td>
<td>1111</td>
<td>1007</td>
<td></td>
</tr>
<tr>
<td>Incidence (/1,000 P-Y)</td>
<td>6.3</td>
<td>7.7</td>
<td>6.3</td>
<td>14.9</td>
<td></td>
</tr>
<tr>
<td>Unadjusted HR (95% CI)</td>
<td>1 (reference)</td>
<td>1.23 (0.45–3.39)</td>
<td>1.01 (0.36–2.89)</td>
<td>2.40 (0.98–5.88)</td>
<td>0.0645</td>
</tr>
<tr>
<td>Adjusted* HR (95% CI)</td>
<td>1 (reference)</td>
<td>1.37 (0.47–3.97)</td>
<td>0.91 (0.31–2.65)</td>
<td>1.93 (0.76–4.90)</td>
<td>0.1166</td>
</tr>
<tr>
<td><strong>All fractures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of cases</td>
<td>14</td>
<td>15</td>
<td>12</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Person-years (P-Y)</td>
<td>1099</td>
<td>1014</td>
<td>1093</td>
<td>981</td>
<td></td>
</tr>
<tr>
<td>Incidence (/1,000 P-Y)</td>
<td>12.7</td>
<td>14.8</td>
<td>11.0</td>
<td>25.5</td>
<td></td>
</tr>
<tr>
<td>Unadjusted HR (95% CI)</td>
<td>1 (reference)</td>
<td>1.16 (0.56–2.41)</td>
<td>0.86 (0.40–1.87)</td>
<td>2.02 (1.05–3.88)</td>
<td>0.0603</td>
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<tr>
<td>Adjusted* HR (95% CI)</td>
<td>1 (reference)</td>
<td>1.21 (0.57–2.56)</td>
<td>0.85 (0.39–1.85)</td>
<td>1.65 (0.83–3.28)</td>
<td>0.0913</td>
</tr>
</tbody>
</table>

*Adjusted for age, BMI, BMD, vitamin D status, calcium intake, medication of osteoporosis and physical activity.

BMI, BMD and vitamin D status, and that the association may not be dose-dependent. Higher incidence of fractures in the highest sway velocity group is attributable to falls, as suggested by results of the 1-year Muramatsu cohort study which showed a higher incidence of falls in the highest quartile of postural sway velocity individuals [4].

Regarding determinants of postural sway in this population, we previously showed that BMI was inversely correlated with the velocity of postural sway, independent of age [4]. This suggested that low BMI is partly responsible for increased postural sway.

Vertebral compression fracture does not necessarily occur with falls. Since the present study only examined symptomatic vertebral fractures, which is often related to falls, we include vertebral fracture as an outcome variable. In the present study, we tried to determine causes of vertebral fracture by interview or analysis of medical case records, and found that at least five of 14 incident vertebral fractures were definitively attributable to falls.

Only a few epidemiologic studies reported impaired balance to be a risk factor for fractures in non-institutionalised elderly. Nguyen et al. [6] showed that the age- and sex-adjusted HR of hip fracture in the highest tertile of body sway was 2.0 (95% CI: 1.2, 3.3) and the middle tertile was 0.7 (95% CI: 0.4, 1.4) compared with the lowest tertile, although they did not show HRs adjusted for covariates such as BMI and vitamin D status. Wagner et al. [7] showed that self-reported impaired balance significantly predicts future hip fracture, osteoporotic fracture and any fracture, with odds ratios of 3.9, 3.0 and 2.2, respectively. Despite being self-reported, data from Wagner et al. suggested a greater impact of balance on osteoporotic fracture than previously thought. Results of the present study were in line with these reports.

As this study focused on Japanese elderly women, characteristics of this population should be noted in relation to fracture. Overall, Japanese women experience a relatively low incidence of fractures. The incidence of all non-vertebral fractures in the present study was calculated to be 12.2 per 1,000 person-years, which is much lower than that reported for Swedish women aged 75 years (41.3 per 1,000 person-years) [14]. The underlying reason for our low fracture rate is unclear, but may be in part attributable to a lower fall incidence in Japanese when compared with Caucasians. Indeed, previous cross-cultural comparisons have demonstrated that the risk of falls in elderly Japanese women is half that of elderly white females [15, 16].

This study may be limited by the number of fracture cases examined. Of note, although we found a significant increase in the incidence of limb and vertebral fractures in the highest sway velocity group, this did not extend to limb fractures only or total fractures.

In conclusion, a large postural sway is associated with future osteoporotic fracture in healthy elderly women, suggesting that measure of postural sway is a useful test for fracture prevention. It is still unknown, however, whether postural sway is associated with all types of fractures, and thus should be addressed in future studies.

Key points

- Postural sway is a predictor of osteoporotic fracture in healthy elderly women, independent of age, BMI, BMD and vitamin D status.
- The association between postural sway and the incidence of osteoporotic fractures may not be dose-dependent.
- The incidence of fracture among Japanese women was lower than that among white women.
Supplementary data

Supplementary data mentioned in the text is available to subscribers in Age and Ageing online.

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Conflicts of interest

None declared.

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Exploring the contributory factors for un-witnessed in-patient falls from the National Reporting and Learning System database

SIR—Healey et al. [1, 2] reported an analysis of 12 months data on accidental falls in English and Welsh hospitals reported to the National Reporting and Learning System (NRLS). Their analyses gave important insights into the key issues, including that falls account for the greatest number of reports (33%) to the NRLS and that 94% of all falls in...