Epidemiology of frailty in elderly Japanese

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Received: August 9, 2016 / Accepted: August 23, 2016

Abstract A healthy elderly person may require nursing care after becoming frail, a condition characterized by slowness, weakness, exhaustion, low activity, and shrinking. Because few cohort studies have examined frailty in detail, the prevalence of frailty among the elderly in Japan is unclear. We examined the prevalence of frailty based on the frailty phenotype established by Fried using a large-scale cohort of randomly selected community-dwelling elderly in Japan. Participants included 871 elderly (446 men and 425 women) aged 65-91 years who participated in the sixth wave examination (July 2008 to July 2010) and seventh wave examination (July 2010 to July 2012) of the National Institute for Longevity Sciences - Longitudinal Study of Aging. The prevalence of shrinking, exhaustion, low activity, slowness, and weakness among the elderly participants was 10.2%, 38.6%, 21.1%, 11.4%, and 15.5%, respectively. The prevalence of frailty characterized by the limitations in 3 or more of these 5 domains was 8.5%. The prevalence of pre-frailty, characterized by limitations in 1 or 2 of 5 domains was 52.2%. Elderly who were diagnosed with frailty and pre-frailty included 3,086,000 people and 17,950,000 people, respectively. These data could contribute to the promotion of prevention and treatment strategies for frailty in Japan.

Keywords: NILS-LSA, frailty phenotype, community-dwelling elderly

Introduction

The Statement for Frailty was published by the Japan Geriatrics Society in 20141). Frailty is an intermediate state between well-being and the need for nursing care1). Frailty is second only to stroke in causing a previously healthy person to require nursing care1). Frailty confers a high risk for adverse outcomes for elderly people, including mortality, institutionalization, falls, and hospitalization2-4). However, frail elderly can return to a healthy state with appropriate interventions5). It is essential for frailty to be understood for promotion of preventive care treatment strategies. As such, studies evaluating adverse outcomes and the prevalence of the frailty are necessary to highlight the risks of frailty.

This review outlines the prevalence of frailty, determined by the modified criteria of the frailty phenotype6), using a large-scale cohort of randomly selected community-dwelling elderly in Japan. Findings from this cohort were compared with the prevalence of frailty calculated in different cohort studies for Japanese elderly, including the Kusatsu Longitudinal Study on Aging and Health7) and the Obu Study of Health Promotion for the Elderly (OSHPE)8).

Overview of the NILS-LSA

The National Institute for Longevity Sciences - Longitudinal Study of Aging (NILS-LSA), a comprehensive longitudinal study of aging, started in November 19977). Participants in this study initially included 2,400 residents aged 40 to 79 years who were age- and sex-stratified random samples selected from the National Center for Geriatrics and Gerontology (former NILS) area. Participants were examined at the NILS-LSA Examination Center every 2 years. All participants provided written informed consent after a detailed explanation of the study.

The NILS-LSA is a facility-based study with access to many types of testing equipment, including magnetic resonance imaging, dual-energy x-ray absorptiometry, and computed tomography for detailed and comprehensive assessments of aging and geriatric diseases. Examinations used for the diagnosis of frailty, such as medical examinations, gene analysis, blood chemical analyses, body com-
position, anthropometry, nutritional analysis, psychological analysis, physical performance, and physical activity, were carried out in the first-wave examination period (1997 to 2000) of the NILS-LSA.

This review presents the prevalence of frailty among elderly who participated in the NILS-LSA. Participants were 871 elderly (446 men and 425 women) who participated in both the sixth-wave examination of the NILS-LSA between July 2008 and July 2010 and the seventh-wave examination of the NILS-LSA between July 2010 and July 2012. Participants were 65-91 years old at the seventh wave examination of the NILS-LSA.

Diagnosis of Frailty in the NILS-LSA

We assessed frailty by 5 domains, including slowness, weakness, exhaustion, low activity, and shrinking. In the original criteria proposed by Fried, frailty was characterized by limitations in 3 or more of these 5 domains, and pre-frailty was characterized by limitations in 1 or 2. Moreover, these diagnoses were associated with a high risk of an incident fall, worsening in activities of daily living (ADL) disability, and early death. We also considered frailty to be characterized by limitations in 3 or more of these 5 domains, and pre-frailty to be characterized by limitations in 1 or 2.

Slowness was defined by a gait speed < 1.0 m/sec using a comfortable gait or disturbances of gait. The frailty phenotype involved sarcopenia. Sarcopenia was defined as a gait speed of < 0.8 m/sec or 1.0 m/sec for the cut-off value of low physical function. However, because few Japanese elderly had a gait speed < 0.8 m/sec and a relationship between a mobility disorder and a gait speed < 1.0 m/sec has been shown, the lower criterion value used in this study might decrease the sensitivity of the findings.

Weakness was defined by the maximum grip strength < 26 kg in men and < 18 kg in women. Grip strength is also part of the criteria for sarcopenia, and these values are in agreement with those defined by the Asian Working Group for Sarcopenia.

The Center for Epidemiologic Studies of Depression (CES-D) scale is widely used to provide an index of the number and distribution of depressive symptoms, and was used in original criteria of frailty phenotype to assess exhaustion. Exhaustion was assessed by a self-report, which included the 2 questions from the CES-D scale: “you felt that everything you did was an effort” and “you could not get going”. Responses included “Rarely or none of the time (less than 1 day)”, “Some or a little of the time (1-2 days)”, “Occasionally or a moderate amount of time (3-4 days)”, and “Most or all of the time (5-7 days)”. Based on the distribution of the answers, if participants did not answer “Rarely or none of the time” to these questions, they were defined as having exhaustion in the NILS-LSA.

A version of the Minnesota leisure time activities questionnaire was used as the original criteria of the frailty phenotype to assess low activity. A questionnaire used to assess physical activity in NILS-LSA was modified from the Minnesota Leisure-time Physical Activity Questionnaire. Low activity was defined as the lowest 20% of leisure-time physical activity by sex, which was equal to the original criteria for the frailty phenotype.

Weight in the prior year was used as the original criteria of frailty phenotype to assess shrinking. Shrinking in this study was defined by ≥ 5% unintentional weight loss in the prior 2 years, because NILS-LSA was designed to perform biennial examinations.

Prevalence of slowness

The prevalence of slowness among elderly participants in the NILS-LSA was 11.4% (Table 1), with a prevalence of 8.5% in men and 14.4% in women (p<0.01; chi-square test).

The OSHPE, which used a gait speed of < 1.0 m/sec for a cut-off value of slowness, reported a prevalence of slowness of 16.8% (Table 1). The Kusatsu cohort study, which used different cut-off values for gait speed by sex and age, reported a prevalence of slowness of 16.7% (Table 1). In the original criteria for the frailty phenotype, the cut-off values for slowness are the slowest 20% of gait speed by sex and height. A uniform cut-off value for gait speed that does not involve age and height appears to help the general and clinical use of this assessment.

Prevalence of weakness

The prevalence of weakness among elderly participants in the NILS-LSA was 15.5% (Table 1), with a prevalence of 10.3% in men and 20.9% in women (p<0.0001; chi-square test).

Based on the original criteria for the frailty phenotype, the cut-off values for weakness were the lowest 20% of grip strength based on sex and height. The Kusatsu cohort study, which used a different cut-off values for grip strength based on sex and age, reported a prevalence of slowness of 18.8% (Table 1). As with gait speed, a uniform cut-off value for grip strength appears to help the general and clinical use of this variable. The OSHPE, which used maximum grip strength measurement cut-off values for weakness of < 26 kg in men and < 17 kg in women reported that a prevalence of weakness of 13.1%.

Prevalence of exhaustion

The prevalence of exhaustion among elderly participants in the NILS-LSA was 38.6% (Table 1) with a prevalence of 34.1% in men and 43.3% in women (p<0.01; chi-square test).

In the Kusatsu cohort study, which assessed exhaustion
The prevalence of low activity among elderly participants in the NILS-LSA was 21.1% (Table 1) with a prevalence of 23.2% and 29.3% in the Kusatsu cohort study and the OSHPE, respectively (Table 1). The evaluation of low activity differed between these studies and the present study (Table 1). Physical activity measured with an accelerometer provides a more objective evaluation of activity than a questionnaire. The development of a cut-off value for physical activity may be essential for general and clinical use.

### Table 1. Prevalence of frailty in Japanese elderly

<table>
<thead>
<tr>
<th>Domains of the frailty phenotype</th>
<th>NILS-LSA</th>
<th>Kusatsu Longitudinal study (2013)&lt;sup&gt;5&lt;/sup&gt;</th>
<th>OSHPE (2013)&lt;sup&gt;6&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Criteria</td>
<td>Prevalence</td>
<td>Criteria</td>
</tr>
<tr>
<td>Slowness</td>
<td>Gait speed &lt; 1.0 m/sec using a comfortable gait or disturbances of gait</td>
<td>11.4%</td>
<td>Gait speed ;</td>
</tr>
<tr>
<td>Weakness</td>
<td>Maximum grip strength:</td>
<td>15.5%</td>
<td>Grip strength:</td>
</tr>
<tr>
<td>Men</td>
<td>≤79 yr</td>
<td>&lt;1.2 m/sec</td>
<td>≤79 yr</td>
</tr>
<tr>
<td>Women</td>
<td>&gt;80 yr</td>
<td>&lt;1.0 m/sec</td>
<td>&gt;80 yr</td>
</tr>
<tr>
<td>Exhaustion</td>
<td>Q7 or Q20 from the CES-D scale:</td>
<td>38.6%</td>
<td>Q7 and Q20 from the CES-D scale:</td>
</tr>
<tr>
<td>Men</td>
<td>≤79 yr</td>
<td>&lt;9.0 kg</td>
<td>“Some or a little of the time”</td>
</tr>
<tr>
<td>Women</td>
<td>≥80 yr</td>
<td>&lt;17.5 kg</td>
<td>or “Occasionally or a moderate amount of time”</td>
</tr>
<tr>
<td>Low activity</td>
<td>Leisure-time physical activity</td>
<td>21.1%</td>
<td>Leisure-time physical activity</td>
</tr>
<tr>
<td>Men</td>
<td>“Do housework: almost none”</td>
<td>9.9%</td>
<td>“Do housework: almost none”</td>
</tr>
<tr>
<td>Women</td>
<td>“Do not housework: ≤1 time/week”</td>
<td>12.6%</td>
<td>“Do not housework: ≤1 time/week”</td>
</tr>
<tr>
<td>Shrinking</td>
<td>≥ 5% unintentional weight loss in prior 2 years</td>
<td>10.2%</td>
<td>≥ 5% unintentional weight loss in prior 1 years</td>
</tr>
</tbody>
</table>

### Diagnosis of Frailty using 5 domains

<table>
<thead>
<tr>
<th></th>
<th>NILS-LSA</th>
<th>Kusatsu Longitudinal study (2013)&lt;sup&gt;5&lt;/sup&gt;</th>
<th>OSHPE (2013)&lt;sup&gt;6&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frailty (limitations in 3 or more)</td>
<td>11.3%</td>
<td>11.3%</td>
<td>11.3%</td>
</tr>
<tr>
<td>Pre-Frailty (limitations in 1-2)</td>
<td>56.3%</td>
<td>56.3%</td>
<td>56.3%</td>
</tr>
<tr>
<td>Non-Frailty (no limitations)</td>
<td>39.3%</td>
<td>39.3%</td>
<td>39.3%</td>
</tr>
</tbody>
</table>

Adapted from references 5 and 6.

NILS-LSA, National Institute for Longevity Sciences - Longitudinal Study of Aging; OSHPE, Obu Study of Health Promotion for the Elderly; CES-D, Center for Epidemiologic Studies Depression.

using the same criteria as the present study, the prevalence of exhaustion was 12.5% (Table 1)<sup>5</sup>. The prevalence of exhaustion may be affected by the differences of the cohort<sup>6</sup>. The OSHPE, which assessed exhaustion using the Geriatric Depression Scale<sup>6</sup>, reported a prevalence of exhaustion of 44.1% (Table 1).

### Prevalence of low Activity

The prevalence of low activity among elderly participants in the NILS-LSA was 21.1% (Table 1) with a prevalence of 19.7% in men and 22.6% in women (not significant; chi-square test). The prevalence of low activity in the Kusatsu cohort study and the OSHPE was 23.2% and 29.3%, respectively (Table 1)<sup>5,6</sup>. The evaluation of low activity differed between these other studies and the present study (Table 1). Physical activity measured with an accelerometer provides a more objective evaluation of activity than a questionnaire. The development of a cut-off value for physical activity may be essential for general and clinical use.
Prevalence of shrinking

The prevalence of shrinking among elderly participants in the NILS-LSA was 10.2% (Table 1) with a prevalence of 7.6% in men and 12.9% in women (p<0.05; chi-square test).

The follow-up period in the NILS-LSA was different that that used in previous studies. An unintentional weight loss ≥ 5% in the prior year among elderly was seen in 7.2% of the Kusatsu cohort5). The OSHPE reported an unintentional weight loss ≥ 5% in the prior 2 years of 12.1% among the elderly6).

Prevalence of frailty

The prevalence of frailty among elderly participants in the NILS-LSA was 8.5% (Table 1), with a prevalence of 5.2% in men and 12.0% in women (p<0.0001; chi-square test). The prevalence of pre-frailty among elderly participants in the NILS-LSA was 52.2% (Table 1), with a prevalence of pre-frailty of 49.6% in men and 55.1% in women.

The prevalence of the frailty appeared to be influenced by the diagnostic criteria used and the different participant’s group assessed18). A systematic review reported that the weighted average prevalence among community-dwelling elderly in foreign countries, including the United States, Canada, Europe, Australia, and Taiwan was 9.9% for frailty (95% confidence interval = 9.6 - 10.2%)18). The Kusatsu cohort study reported a prevalence of frailty among the elderly of 5.7%5). The OSHPE reported a prevalence of frailty of 11.3%6). Some participants of NILS-LSA and the OSHPE reside in the same residential area6,7). The principal difference in the prevalence of frailty between the Kusatsu cohort study, the OSHPE, and the NILS-LSA may be due to the differences in the prevalence of exhaustion5,6). The difference in the prevalence of frailty between the NILS-LSA and OSHPE was small5). It was estimated that approximately 10% of Japanese elderly people were frail when the diagnosis was made based on the 5 domains identified. Moreover, pre-frailty was diagnosed in approximately half of elderly participants in the NILS-LSA (Table 1).

Aging has been shown to increase the prevalence of frailty4,8,18,19). It has also been reported that the prevalence of the frailty is higher in women compared with men4,8,18,19). The present results among elderly participants in the NILS-LSA agree with these findings (Fig. 1). In particular, the prevalence of frailty in women aged ≥ 85 years is higher than that of men aged ≥ 85 years. A difference of life expectancy between men and women might lead to a higher prevalence of frailty in women than men19). Additionally, the higher prevalence of the frailty in women may be due to the fact that women have lower muscle mass and muscle strength than men19).

Most of studies on frailty reported that there was a greater prevalence of pre-frailty than frailty4,18,20). Development of nutritional and exercise interventions to keep pre-frailty from progressing to frailty is essential.

Estimate of the prevalence of frailty in Japan

The prevalence of frailty in Japan was calculated by the prevalence of frailty in the NILS-LSA and values of the elderly population of Japan as at December 2015 (provided by the Ministry of Internal Affairs and Communications).

Fig. 1  Relationship between age and stage of frailty.
Trend p value was determined using the Cochran–Mantel–Haenszel test.
Table 2. The cross-sectional relationship between the stage of frailty and medical histories among the elderly participants in NILS-LSA

<table>
<thead>
<tr>
<th></th>
<th>Men (n=446)</th>
<th>Women (n=425)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-frailty (n=202)</td>
<td>Pre-frailty (n=221)</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>72.8 ± 0.4</td>
<td>74.8 ± 0.4</td>
</tr>
<tr>
<td>Body height (cm)</td>
<td>163.8 ± 0.4</td>
<td>162.7 ± 0.4</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>61.7 ± 0.6</td>
<td>60.1 ± 0.6</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>23.0 ± 0.2</td>
<td>22.7 ± 0.2</td>
</tr>
<tr>
<td>Percent of body fat</td>
<td>22.6 ± 0.3</td>
<td>23.3 ± 0.3</td>
</tr>
<tr>
<td>Skeletal muscle index (kg/m²)</td>
<td>7.3 ± 0.1</td>
<td>7.1 ± 0.1</td>
</tr>
<tr>
<td>MMSE score</td>
<td>27.8 ± 0.1</td>
<td>27.1 ± 0.1</td>
</tr>
<tr>
<td>CES-D score</td>
<td>11.6 ± 0.3</td>
<td>15.5 ± 0.3</td>
</tr>
<tr>
<td>Short Form-36 Physical fitness score</td>
<td>91.9 ± 1.0</td>
<td>83.1 ± 1.0</td>
</tr>
<tr>
<td>Certification of Needed Support or Needed Long-Term Care (n)</td>
<td>2 1.0%</td>
<td>4 1.8%</td>
</tr>
<tr>
<td>Sarcopenia (n)</td>
<td>0 0.0%</td>
<td>30 13.6%</td>
</tr>
<tr>
<td>Stroke (n)</td>
<td>13 6.4%</td>
<td>23 10.4%</td>
</tr>
<tr>
<td>Hypertension (n)</td>
<td>94 46.5%</td>
<td>120 54.3%</td>
</tr>
<tr>
<td>Ischemic heart disease (n)</td>
<td>18 8.9%</td>
<td>26 11.8%</td>
</tr>
<tr>
<td>Hyperlipidemia (n)</td>
<td>55 27.2%</td>
<td>51 23.1%</td>
</tr>
<tr>
<td>Kidney disease (n)</td>
<td>8 4.0%</td>
<td>4 1.8%</td>
</tr>
<tr>
<td>Liver disease (n)</td>
<td>6 3.0%</td>
<td>12 5.4%</td>
</tr>
<tr>
<td>Gall stone or cholecystitis (n)</td>
<td>18 8.9%</td>
<td>25 11.4%</td>
</tr>
<tr>
<td>Diabetes (n)</td>
<td>24 11.9%</td>
<td>26 11.8%</td>
</tr>
<tr>
<td>Gastric ulcer or duodenal ulcer (n)</td>
<td>48 23.8%</td>
<td>43 19.5%</td>
</tr>
<tr>
<td>Chronic bronchitis (n)</td>
<td>4 2.0%</td>
<td>7 3.2%</td>
</tr>
<tr>
<td>Anemia (n)</td>
<td>8 4.0%</td>
<td>12 5.4%</td>
</tr>
<tr>
<td>Osteoporosis (n)</td>
<td>7 3.5%</td>
<td>9 4.1%</td>
</tr>
<tr>
<td>Rheumatism (n)</td>
<td>2 1.9%</td>
<td>4 1.8%</td>
</tr>
<tr>
<td>Knee osteoarthritis (n)</td>
<td>16 7.9%</td>
<td>21 9.5%</td>
</tr>
<tr>
<td>Gout or hyperuricemia (n)</td>
<td>24 11.9%</td>
<td>26 11.8%</td>
</tr>
<tr>
<td>Parathyroid disease (n)</td>
<td>0 0.0%</td>
<td>0 0.0%</td>
</tr>
<tr>
<td>Thyroid disease (n)</td>
<td>6 3.0%</td>
<td>5 2.3%</td>
</tr>
<tr>
<td>Cancer (n)</td>
<td>14 6.9%</td>
<td>29 13.1%</td>
</tr>
<tr>
<td>Bone fracture (n)</td>
<td>52 25.7%</td>
<td>71 32.1%</td>
</tr>
</tbody>
</table>

Values are means ± SE or number (%). *p<0.05, **p<0.01, ***p<0.0001
Sarcopenia was diagnosed by the criteria of the Asian Working Group for Sarcopenia. Mini mental state exam (MMSE) score was acquired from 442 men and 422 women. Center for Epidemiologic Studies Depression (CES-D) score was acquired from 445 men and 425 women. SF-36 score was acquired from 422 women. The number with gallstones or cholecystitis was acquired from 445 men.
tions). Elderly who were diagnosed with frailty included 766,000 men and 2,320,000 women. Elderly who were diagnosed with pre-frailty included 7,300,000 men and 10,650,000 women. Because homebound, institutionalized, or hospitalized patients are not included in participants of NILS-LSA, the population of the frailty may be higher than the present estimations.

Outcome of frailty

One adverse outcome of frailty is an early death\(^6\). The relationship between early death and frailty in Japanese elderly is unknown. The Kusatsu cohort study reported that the cut-off value for the Kihon Checklist to discriminate frailty and non-frailty was 3/4 point\(^5\). High mortality was associated with ≥ 4 points on the Kihon Checklist\(^5\). In addition, the development of ADL impairments, and the onset of service use under the long-term care insurance was associated with ≥ 4 points on the Kihon Checklist\(^5\). Studies evaluating the association between assessment criteria and adverse outcomes are necessary to validate the clinical utility of these criteria.

The OSHPE reported a cross-sectional relationship between frailty and mild cognitive impairment (MCI), with a combined prevalence of frailty and MCI of 2.7% among elderly participants\(^3\). Table 2 shows the cross-sectional relationship between the stage of frailty and the medical histories among elderly participants in NILS-LSA. The progress of the stage of frailty increased age in men and women. Body weight, body height, Mini Mental State Exam score, CES-D score, and Short-Form 36 Physical fitness scores worsened as the stage of frailty worsened in men and women. The number of patients who met the criteria for Certification of Needed Support or Needed Long-Term Care and sarcopenia increased as the stage of frailty worsened in men and women. Skeletal muscle index was not changed by frailty in women. The number of patients with stroke, hypertension, ischemic heart disease, liver disease, knee osteoarthritis, and parathyroid disease increased as the stage of frailty worsened only in women. In contrast, the numbers of patients with anemia, rheumatism, and cancer increased as the stage of frailty worsened only in men. Interestingly, the number patients with hyperlipidemia decreased as the stage of frailty worsened only in men.

Conclusion

More than 6 million people in Japan have received certification of long-term care need\(^9\). Because a post-baby boom generation called “Dankai no Sedai” will represent the latter-stage elderly until 2025, it is predicted that the number of elderly people requiring care will increase\(^2\). An extension of healthy life expectancy is essential to avoid a crisis within the social security budget. It is necessary for the study of frailty to be promoted broadly.

Conflict of Interests

The authors declare that there are no conflict of interests regarding the publication of this article.

Acknowledgments

The authors thank all of the participants, health professionals, and researchers from the Section of the NILS-LSA, National Center for Geriatrics and Gerontology, who were involved in data collection and analyses.

This work was supported by the Japan Society for the Promotion of Science KAKENHI (15K00857 and 16H03264) and the Research Funding for Longevity Sciences (25-22 and 28-40) from the National Center for Geriatrics and Gerontology, Japan.

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