The Effect of Respiratory Rehabilitation for the Frail Elderly: a Pilot Study

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Objective: To analyze the effects of respiratory rehabilitation on the activities of daily living (ADL) and quality of life (QOL) in community-dwelling frail elderly.

Design: Pilot intervention study after a one-year period of observation.

Setting: Day care facility in a rehabilitation hospital.

Subjects: Thirty community-dwelling frail elderly using rehabilitation services

Intervention: After a one-year observation period of usual rehabilitation, 30 participants were given 12 rehabilitation sessions that included respiratory rehabilitation (three sessions a week for four weeks).

Main Measures: The measurement was performed approximately one year before the 12 rehabilitation sessions (initial measurements) and one year after the intervention (final measurements). The measures included assessments of ADL, QOL, and respiratory function.
evaluation), prior to training (pre-training evaluation), and after the sessions (post-training evaluation). Primary outcome measures included: respiratory function, swallowing function, ADL, and QOL. Secondary outcome measures included: depressive score, exercise tolerance, 6-minute walk distance, thorax flexibility, and muscle strength (knee extension, grip, and abdominal). QOL were estimated using questionnaires.

Results: Swallowing function, ADL, QOL (SF8 physical and mental summary score), respiratory function, and physical function were significantly reduced during usual rehabilitation (between the initial evaluation and pre-training evaluation), whereas swallowing function, ADL, QOL (SF8 physical component summary score [PCS]), respiratory function, exercise tolerance, 6-minute walk distance, thorax flexibility, and muscle strength (knee extension) were significantly improved during respiratory rehabilitation (between the pre-training evaluation and post-training evaluation).

Conclusions: Our results suggest that a usual rehabilitation program without respiratory training is not sufficient for the frail elderly to maintain their ADL and QOL, and furthermore that respiratory rehabilitation can help improve their ADL and QOL as well as their swallowing and respiratory function.

Keywords: respiratory rehabilitation, community-dwelling frail elderly, swallowing function, ADL, QOL

Introduction

Lower respiratory infections are the fourth leading cause of death in the world.1 In Japan, pneumonia is the third leading cause of death in the elderly, surpassing cerebrovascular disease, and it is the number one cause of death in the elderly over 90 years of age.2 Over 90% of deaths from pneumonia occur in the elderly, and of these, about 60% or more are said to be cases of aspiration pneumonia.3 Reduced swallowing function and respiratory functions are major risk factors for aspiration pneumonia. Fukai4 reported that the risk of aspiration pneumonia increased with care level in elderly in long-term care. In addition, Yoneyama et al5 reported that aspiration pneumonia was a leading cause of hospitalization and mortality among older adults, particularly in elderly in long-term care.

In the elderly, ventilation volume is known to decrease with age, negatively affecting their activities of daily living (ADL).6 Respiratory disabilities are associated with a decrease in exercise tolerance and can lead to disuse syndrome. Therefore, prevention of functional respiratory decline is an important factor when considering how to prevent long-term care for elderly. It is well known that respiratory functions are associated with Quality of life (QOL) in chronic obstructive pulmonary disease (COPD) patients.7 The association between respiratory functions and QOL in community-dwelling frail elderly, however, has not yet been elucidated. It is possible that previous study8 might have shown improvement of respiratory function on pulmonary rehabilitation in the elderly due to inclusion of patients with COPD, reflecting the effect of pulmonary rehabilitation on patients with COPD. From our previous study, elder patients without respiratory disease also have gain significant benefit from pulmonary rehabilitation. Therefore, we conducted to clarify the effects of respiratory rehabilitation on community-dwelling frail elderly without respiratory diseases. We conducted a cross-sectional study of 87 community-dwelling frail elderly who used rehabilitation services through long-term care insurance (support level 1–2 or care level 1–3), and who showed an association between their respiratory function and QOL and ADL.9 Approximately one year after the cross-sectional study, we re-evaluated the participants’ respiratory function and offered rehabilitation programs that included respiratory training.

Methods

Participants

Participants in this study had also taken part in our cross-sectional study and were users of a day care
facility in Yasato Rehabilitation Hospital in Ibaraki Prefecture, Japan. The inclusion criteria for the original cross-sectional study were as follows: elderly who were certified to require support level 1–2, or care level 1–3; time since acute disease onset was 6 months or more; Mini-Mental State Examination (MMSE) score of >21; absence of COPD or any respiratory disease; and a forced expiratory volume in 1 second % (FEV1%) of ≥70%.

Approximately 1 year later (August and September, 2014), we recruited the participants for this study from the subjects of the cross-sectional study who had continued rehabilitation at the same facility (Figure 1). We excluded the patients with moderate and severe cardiac disease (New York Heart Association Classification of III or IV).11

Study protocol
This study was designed as an intervention study after a one-year period of observation, with no control group. Participants were given 12 rehabilitation sessions that included respiratory rehabilitation (three sessions per week, for four weeks). Each 20-minute session was held once a day and comprised 10 minutes of respiratory rehabilitation in addition to 10 minutes of usual rehabilitation. Baseline measures of each participant’s demographics and characteristics were assessed prior to interventions. Outcome measures were evaluated three times: approximately one year before (at the previous cross-sectional study, initial evaluation), prior to training (pre-training evaluation), and after the 12 sessions (post-training evaluation).

Respiratory rehabilitation program
The intervention consisted of the following: respiratory muscle training, cough exercise, diaphragmatic muscle training, stretching exercise, and home exercise.12 For the respiratory muscle training, participants performed three sets of 10 breaths through a commercially available hand-held resistance device (Threshold PEP; Chest Co, Japan) set at 60% of the individual’s maximum expiratory mouth pressure, with resting periods of 1 minute between sets.13,14 A threshold PEP costs 3,000 Japanese yen. The cough exercise was performed using 3 sets of 10 active coughs.15,16 For diaphragmatic muscle training, each participant performed 30 maximal voluntary diaphragmatic contractions in the supine position with a moderately heavy weight (range: 1–3 kg) placed on the anterior abdominal wall to resist diaphragmatic descent.17 As for home exercise, the participants received guidance on pursed-lip breathing and cough training and were asked to do 30 sets of each training every day.18

Usual rehabilitation program
The usual rehabilitation program contained a range of motion exercise, muscle strength training, balance training, gait training, and ADL exercise, but did not contain respiratory rehabilitation.

Japanese long-term care insurance system
Long-term care insurance is a public social insurance program run by municipal governments to provide long-term care services. Insured persons aged 40 and older are eligible for long-term care insurance. Long-term care insurance services include ‘services provided at home,’ ‘services provided at care facilities,’ and ‘locality-oriented services.’ The users are classified into
seven categories (Support Levels 1 and 2 and Care Levels 1 to 5), depending on the severity of the care need; ‘Support Level 1’ being the most mild and ‘Care Level 5’ the most severe. The limitations of the services provided are determined according to these categories.\textsuperscript{19}

**Assessment**

All assessment was done by physical therapists trained to perform standardized assessment procedures. Primary outcome measures included: respiratory function, swallowing function, ADL, and QOL. Secondary outcome measures included: depression, exercise tolerance, 6-minute walk distance, thorax flexibility, and muscle strength (knee extension, grip, and abdominal). QOL were estimated using questionnaires.

1. **Respiratory function**

Respiratory function was evaluated using a respiratory function test with an auto spirometer (Vitalopower KH-801).\textsuperscript{11} The following parameters related to respiratory function were measured: (1) lung volume fraction, (2) air flow volume, (3) vital capacity (VC), (4) forced vital capacity (FVC), (5) forced expiratory volume in 1.0 s (FEV1), (6) percentage of FEV1 (FEV1%), (7) peak expiratory flow rate (PEF), (8) and peak expiratory cough flow (PECF). Respiratory muscle strength was assessed through measurement of maximum expiratory mouth pressure (MEP) and maximum inspiratory mouth pressure (MIP). PECF was defined as the highest point of the flow volume curve obtained during a cough, and the maximum value of three measurements was used for analysis. All predictive values were calculated using the standard regression equation published by the Japanese Respiratory Society.\textsuperscript{20,21}

2. **Swallowing function**

Swallowing function was evaluated using the Dysphagia Risk Assessment for the Community-Dwelling Elderly test (DRACE)\textsuperscript{22} and the Repetitive Saliva Swallowing Test (RSST).\textsuperscript{23} The DRACE test includes 12 questions with possible answers of “not at all” (scoring 0 points), “sometimes” (scoring 1 point), and “frequently” (scoring 2 points).

A high score is indicative of severe dysphagia. In the RSST, the subject was instructed to repeatedly swallow for 30 s. Successful swallowing was confirmed by placing a finger over the laryngeal prominence–hyoid bone of the subject and by palpation of the downward movement of the laryngeal elevation occurring during swallowing while exercising. We measured the number of times the subject swallowed in 30 s.

3. **ADL evaluation**

ADL was evaluated using the Functional Independence Measure (FIM) scale by the physical therapist. The FIM comprises 18 items, each with a maximum score of 7 and a minimum score of 1, and the maximum total score is 126 points. The 18-item FIM can be divided into 13 items assessing motor ADL (including 6 items for self-care, 2 items for sphincter control, 3 items for transfer, and 2 items for locomotion) and 5 items assessing cognitive ADL (including 2 items for communication and 3 items for social cognition).\textsuperscript{24}

4. **QOL evaluation**

We assessed QOL using the Medical Outcome Study 8-Item Short-Form Health Survey (MOS-SF8). The MOS-SF8 measures 8 health domains: (1) general health, (2) physical function, (3) role function (body), (4) body pain, (5) social function, (6) overall sense of well-being, (7) vitality, and (8) emotional function. The SF8 scores include both a physical component summary score (PCS) and a mental component summary score (MCS).\textsuperscript{25}

5. **Strength evaluation**

Grip, abdominal muscle, and knee extension strengths were measured with the participant in a sitting position. Each test was repeated three times, and the maximum value was used for further analyses.

*Grip strength*

Grip strength was measured using a hand dynamometer.

*Abdominal muscle strength*

Rectus abdominal muscle and right and left oblique muscle strengths were measured using the Manual Muscle Test (MMT). Muscle strengths were measured at levels 0 to 5.
Knee extension strength
Quadriceps strength was measured using a hand-held dynamometer (HHD; EG-230 SAKAI Medical Co.). The strength was measured in kgf/kg.

6. Thorax flexibility
Chest expansion
The width of respiratory motion was measured by subtracting the value of the chest circumference at maximum expiration from that at maximum inspiration.
Trunk measurement of joint motion
The range of motion of the thoracolumbar spine (flexion and extension, side bending and rotation) was measured using a goniometer.

7. Exercise tolerance
Exercise tolerance was measured using the 6-minute walk test (6MWT), which measures the distance an individual can walk in six minutes, also called the ambulatory distance. Percutaneous oxygen saturation (SpO2) was measured before and after the 6-minute walk using a saturation pulse oximeter. Heart rate, systolic blood pressure, diastolic blood pressure, respiratory rate, and rate of perceived exertion (Borg scale) were also measured before and after the walk.

8. Depression status
The possible presence and level of depression were evaluated using the Geriatric Depression Scale (GDS).

9. Instrumental ADL
Instrumental ADL (IADL) was evaluated using the Tokyo Metropolitan Institute of Gerontology (TMIG) Index of CompetenceActivities Capability Assessment.

Statistical analysis
We used SPSS version 21.0d for all statistical analyses. Comparisons were made using paired t-test, repeated measured one-way analysis of variance and Tukey method. Statistical significance was set at $P < .05$.

Ethical considerations
This study was conducted with the approval of the ethics committee of the University of Tsukuba (approval number: 858). All participants provided written informed consent after receiving a full written description of the study.

Results
Figure 1 shows the flow of patients’ participation in this study. A total of 60 patients who had continued rehabilitation at the same facility were assessed for eligibility. Of those 60 patients, 25 did not consent to the study; four had severe cardiac disease; and 31 received respiratory rehabilitation. One patient could not continue rehabilitation because of acute exacerbation of Parkinson disease. Therefore, post-training evaluation data were obtained for a total of 30 patients who completed the study protocol. Characteristics of participants and non-participants are presented in Table 1. No differences were observed between the 2 groups. On average, participants had received usual rehabilitation for 60 minutes a week over the one-year observation period. No participant withdrew from the study because of adverse effects. Change of outcome measures are shown in Table 2 and Figure 2. Swallowing function, ADL, QOL (SF8 PCS & MCS), respiratory function, and physical function (grip strengths, abdominal muscle, and knee extension strengths, thorax flexibility, and exercise tolerance) were significantly reduced during usual rehabilitation (between initial and pre-evaluation), whereas swallowing function, ADL, QOL (PCS), respiratory function, exercise tolerance, 6-minute walk distance, thorax flexibility, and muscle strength (knee extension) were significantly improved during respiratory rehabilitation (between pre- and post-evaluation).

Discussion
Our results suggest that respiratory rehabilitation is beneficial to community-dwelling frail elderly. The participants’ respiratory and swallowing function, ADL, and QOL had each decreased after one year, despite receiving usual rehabilitation. However this was reversed by the 12 20-minute sessions of respiratory rehabilitation held over 4 weeks. The results obtained in this trial indicate that respiratory function, swallowing function, ADL, and QOL can be improved or main-
tained by including respiratory rehabilitation sessions to a program of usual rehabilitation.
Matsuo et al⁸ reported the effects of respiratory rehabilitation in 22 subjects’ of community-dwelling frail elderly without respiratory disease. The respiratory program consisted of 30 minutes sessions, once a day, for 4 weeks, and they reported that this program did improve subjects’ respiratory function. We think, however, that this evidence is insufficient to establish the effects of respiratory rehabilitation for the frail elderly in general, because they did not measure respiratory function in their subjects and might have included those with decreased respiratory function, thus it remains possible that only frail elderly with decreased respiratory function responded respiratory rehabilitation.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean ± SD</th>
<th>N (%)</th>
<th>Initial participants (n = 31)</th>
<th>Non-participants (n = 25)</th>
<th>Pre participants (n = 31)</th>
<th>Pre non-participants (n = 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, female</td>
<td>20 (64%)</td>
<td>18 (72%)</td>
<td>n-s</td>
<td>22.9 ± 6.7</td>
<td>22.4 ± 8.4</td>
<td>n-s</td>
</tr>
<tr>
<td>Age</td>
<td>83.5 ± 7.6</td>
<td>82.1 ± 8.1</td>
<td>n-s</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>23.1 ± 5.9</td>
<td>22.8 ± 4.7</td>
<td>n-s</td>
<td>1.7 ± 1.3</td>
<td>1.6 ± 1.5</td>
<td>n-s</td>
</tr>
<tr>
<td>Certified as requiring support or care (levels)</td>
<td>1.4 ± 1.2</td>
<td>1.3 ± 1.4</td>
<td>n-s</td>
<td>60 ± 12.6</td>
<td>60 ± 12.6</td>
<td>n-s</td>
</tr>
<tr>
<td>Mean time of usual rehabilitation duration for 1 year (min/week)</td>
<td>—</td>
<td>—</td>
<td>60 ± 12.6</td>
<td>60 ± 12.6</td>
<td>n-s</td>
<td></td>
</tr>
<tr>
<td>Main Diseases</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Stroke</td>
<td>16 (52%)</td>
<td>11 (44%)</td>
<td>n-s</td>
<td>16</td>
<td>11</td>
<td>n-s</td>
</tr>
<tr>
<td>Fracture</td>
<td>11 (35%)</td>
<td>9 (36%)</td>
<td>n-s</td>
<td>11</td>
<td>9</td>
<td>n-s</td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>9 (29%)</td>
<td>8 (32%)</td>
<td>n-s</td>
<td>9</td>
<td>9</td>
<td>n-s</td>
</tr>
<tr>
<td>Parkinson diseases</td>
<td>1 (3%)</td>
<td>0 (0%)</td>
<td>n-s</td>
<td>1</td>
<td>0</td>
<td>n-s</td>
</tr>
<tr>
<td>Variables</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>VC (%predicted)</td>
<td>89.4 ± 16.6</td>
<td>87.3 ± 18.1</td>
<td>n-s</td>
<td>78.8 ± 14.9</td>
<td>76.4 ± 13.1</td>
<td>n-s</td>
</tr>
<tr>
<td>FEV1% (%)</td>
<td>86.4 ± 9.3</td>
<td>87.7 ± 11.4</td>
<td>n-s</td>
<td>79.6 ± 8.2</td>
<td>81.2 ± 9.5</td>
<td>n-s</td>
</tr>
<tr>
<td>PECF (L/min)</td>
<td>236.7 ± 80</td>
<td>249.7 ± 87</td>
<td>n-s</td>
<td>177.1 ± 60</td>
<td>183.2 ± 68</td>
<td>n-s</td>
</tr>
<tr>
<td>Knee extension (kgf/kg)</td>
<td>13.5 ± 6.6</td>
<td>15.1 ± 7.8</td>
<td>n-s</td>
<td>10.3 ± 5.3</td>
<td>11.9 ± 6.2</td>
<td>n-s</td>
</tr>
<tr>
<td>6MD (m)</td>
<td>236.7 ± 80.4</td>
<td>228.9 ± 74.7</td>
<td>n-s</td>
<td>177.1 ± 60.3</td>
<td>180.4 ± 68.9</td>
<td>n-s</td>
</tr>
<tr>
<td>DRACE</td>
<td>2.8 ± 2.9</td>
<td>2.6 ± 2.4</td>
<td>n-s</td>
<td>6.8 ± 4.4</td>
<td>6.0 ± 3.8</td>
<td>n-s</td>
</tr>
<tr>
<td>RSST</td>
<td>3.6 ± 0.7</td>
<td>3.3 ± 0.5</td>
<td>n-s</td>
<td>2.2 ± 1.0</td>
<td>2.5 ± 0.8</td>
<td>n-s</td>
</tr>
<tr>
<td>FIM</td>
<td>118.5 ± 6</td>
<td>119.3 ± 6</td>
<td>n-s</td>
<td>108.1 ± 9</td>
<td>110.2 ± 10</td>
<td>n-s</td>
</tr>
<tr>
<td>SF8 (PCS)</td>
<td>48.8 ± 6.2</td>
<td>46.8 ± 5.7</td>
<td>n-s</td>
<td>42.1 ± 5.8</td>
<td>43.5 ± 6.1</td>
<td>n-s</td>
</tr>
<tr>
<td>SF8 (MCS)</td>
<td>48.7 ± 6.9</td>
<td>49.5 ± 7.1</td>
<td>n-s</td>
<td>44.1 ± 7.4</td>
<td>49.1 ± 7.9</td>
<td>n-s</td>
</tr>
</tbody>
</table>

* p < .05  **p < .01  ns = not significant
† Fisher exact test.
Unpaired t test.
VC: vital capacity; FEV1: forced expiratory volume at 1 second
PECF: peak expiratory cough flow
RSST: repetitive saliv a swallowing test
DRACE: Dysphagia risk assessment for community-dwelling elderly
FIM: Functional Independence Measure
SF8PCS: Physical component summary
SF8MCS: Mental component summary
It is well known that respiratory rehabilitation for COPD patients improves their ADL and QOL. 29 Several trials of respiratory rehabilitation have been conducted in elderly patients with a decrease in swallowing function because of stroke or neuro-muscular disease. 30, 31 However, the effects of respira-

<table>
<thead>
<tr>
<th>Variables</th>
<th>Initial</th>
<th>Pre</th>
<th>Post</th>
<th>Initial-Pre</th>
<th>Pre-Post</th>
<th>Initial-Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>VC (%predicted)</td>
<td>89.4 ± 16.6</td>
<td>78.8 ± 14.9</td>
<td>87.9 ± 12.6</td>
<td>*</td>
<td>*</td>
<td>n-s</td>
</tr>
<tr>
<td>FVC (%predicted)</td>
<td>87.5 ± 16.5</td>
<td>77.5 ± 14.8</td>
<td>84.3 ± 10.6</td>
<td>**</td>
<td>n-s</td>
<td>n-s</td>
</tr>
<tr>
<td>FEV1 (%predicted)</td>
<td>88.2 ± 15.9</td>
<td>79.8 ± 15.9</td>
<td>89.0 ± 15.9</td>
<td>**</td>
<td>**</td>
<td>n-s</td>
</tr>
<tr>
<td>FEV1% (%)</td>
<td>86.4 ± 9.3</td>
<td>79.6 ± 8.2</td>
<td>85.3 ± 9.7</td>
<td>**</td>
<td>**</td>
<td>n-s</td>
</tr>
<tr>
<td>PEF (%predicted)</td>
<td>65.5 ± 21.2</td>
<td>40.5 ± 16.4</td>
<td>54.8 ± 11.8</td>
<td>*</td>
<td>*</td>
<td>n-s</td>
</tr>
<tr>
<td>PECF (L/min)</td>
<td>236.7 ± 80</td>
<td>177.1 ± 60</td>
<td>223.8 ± 77</td>
<td>**</td>
<td>*</td>
<td>n-s</td>
</tr>
<tr>
<td>MIP (%predicted)</td>
<td>—</td>
<td>21.8 ± 16.0</td>
<td>29.5 ± 17.3</td>
<td>—</td>
<td># #</td>
<td>—</td>
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<tr>
<td>MEP (%predicted)</td>
<td>—</td>
<td>22.2 ± 11.2</td>
<td>30.9 ± 11.5</td>
<td>—</td>
<td># #</td>
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<tr>
<td>Muscle strength (kgf/kg)</td>
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<tr>
<td>Knee extension</td>
<td>13.5 ± 6.6</td>
<td>10.3 ± 5.3</td>
<td>14.2 ± 4.9</td>
<td>**</td>
<td>**</td>
<td>n-s</td>
</tr>
<tr>
<td>Grip strength (kg)</td>
<td>14.5 ± 7.6</td>
<td>13.8 ± 6.1</td>
<td>14.2 ± 5.2</td>
<td>n-s</td>
<td>n-s</td>
<td>n-s</td>
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<tr>
<td>Thoracolumbar spine ROM (°)</td>
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<tr>
<td>Side bending</td>
<td>19.1 ± 11.2</td>
<td>14.5 ± 15.4</td>
<td>23.1 ± 6.8</td>
<td>*</td>
<td>*</td>
<td>n-s</td>
</tr>
<tr>
<td>Rotation</td>
<td>24.6 ± 12.6</td>
<td>18.8 ± 13.5</td>
<td>27.6 ± 11.2</td>
<td>*</td>
<td>*</td>
<td>n-s</td>
</tr>
<tr>
<td>Chest expansion</td>
<td>2.1 ± 1.0</td>
<td>1.7 ± 0.8</td>
<td>2.9 ± 0.9</td>
<td>*</td>
<td>*</td>
<td>n-s</td>
</tr>
<tr>
<td>6MD (m)</td>
<td>236.7 ± 80.4</td>
<td>177.1 ± 60.3</td>
<td>223.8 ± 77.6</td>
<td>*</td>
<td>*</td>
<td>n-s</td>
</tr>
<tr>
<td>Borg scale</td>
<td>3.8 ± 0.9</td>
<td>4.5 ± 0.6</td>
<td>3.5 ± 0.6</td>
<td>**</td>
<td>**</td>
<td>n-s</td>
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<tr>
<td>Swallowing function</td>
<td></td>
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<td></td>
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<tr>
<td>DRACE</td>
<td>2.8 ± 2.9</td>
<td>6.8 ± 4.4</td>
<td>3.7 ± 3.1</td>
<td>**</td>
<td>**</td>
<td>n-s</td>
</tr>
<tr>
<td>RSST</td>
<td>3.6 ± 0.7</td>
<td>2.2 ± 1.0</td>
<td>3.3 ± 0.8</td>
<td>**</td>
<td>**</td>
<td>n-s</td>
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<tr>
<td>IADL</td>
<td>6.1 ± 4.0</td>
<td>4.1 ± 2.1</td>
<td>4.7 ± 3.5</td>
<td>**</td>
<td>n-s</td>
<td>n-s</td>
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<tr>
<td>ADL</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>FIM (Motor)</td>
<td>84.0 ± 7.0</td>
<td>77.1 ± 11.8</td>
<td>82.7 ± 8.2</td>
<td>*</td>
<td>*</td>
<td>n-s</td>
</tr>
<tr>
<td>FIM</td>
<td>118.5 ± 8</td>
<td>108.1 ± 15</td>
<td>115.4 ± 10</td>
<td>*</td>
<td>*</td>
<td>n-s</td>
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<tr>
<td>QOL</td>
<td></td>
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<tr>
<td>SF8 (PCS)</td>
<td>48.8 ± 6.2</td>
<td>42.1 ± 5.8</td>
<td>47.4 ± 5.2</td>
<td>*</td>
<td>*</td>
<td>n-s</td>
</tr>
<tr>
<td>SF8 (MCS)</td>
<td>48.7 ± 6.9</td>
<td>44.1 ± 7.4</td>
<td>46.8 ± 8.5</td>
<td>**</td>
<td>n-s</td>
<td>n-s</td>
</tr>
</tbody>
</table>

n = 30  *p < .05  **p < .01  ns = not significant Mean ± SD
#: paired t-test  #: repeated ANOVA
VC: vital capacity; FVC: forced vital capacity; FEV1: forced expiratory volume at 1 second
PEF: peak expiratory flow; PECF: peak expiratory cough flow
MIP: PImax = maximal inspiratory pressure; MEP: PEmax = maximal expiratory pressure
ROM: range-of-motion; Borg scale: rate of perceived exertion
RSST: repetitive saliv a swallowing test
DRACE: Dysphagia risk assessment for community-dwelling elderly
IADL: Instrumental Activity of Daily Living
FIM: Functional Independence Measure
SF8PCS: Physical component summary
SF8MCS: Mental component summary

It is well known that respiratory rehabilitation for COPD patients improves their ADL and QOL. 29 Several trials of respiratory rehabilitation have been conducted in elderly patients with a decrease in swallowing function because of stroke or neuro-muscular disease. 30, 31 However, the effects of respira-
tory rehabilitation have not yet been established for the ADL and QOL for frail elderly. To the best of our knowledge, the present study is the first trial to show the efficacy of respiratory rehabilitation to improve the ADL and QOL in frail elderly.

Decreased swallowing function and cough function are major risk factors for aspiration pneumonia, especially in the frail elderly. McKinstry et al. reported 632 COPD patients with dysphasia who participated in an Outpatient Pulmonary Rehabilitation Program. This program consisted of 60 minutes sessions, once a day, three days per week, for eight weeks, and improved participants’ swallowing-related QOL issues and overall self-management of chronic respiratory disease and dysphagia. We have shown that swallowing function and cough function (PECF) were improved by respiratory rehabilitation in frail elderly without COPD. Cough is an important mechanism to protect from aspiration, and adequate voluntary coughing reduces the risk of aspiration pneumonia. It requires the coordinated activation of respiratory muscles (MIP and MEP) and intrinsic laryngeal muscles. Our data suggests that MIP and MEP are improved in frail elderly by respiratory rehabilitation, which further suggests that respiratory rehabilitation might be effective in preventing aspiration pneumonia for frail elderly. Decrease in respiratory function in subjects without respiratory disease is attributable to reduction of respiratory muscle strength. Our findings suggest that respiratory muscle training during respiratory rehabilitation could strengthen those muscles and bring an improvement in respiratory function in frail elderly.

It is important not only for Japan but also other countries to prevent disability in elderly. The Japanese government has developed a disability prevention program using “Secondary Preventive Services” for pre-frail elderly (high-risk approach). Despite undergoing of usual rehabilitation for 60 minutes per week for one year, the pre-training evaluation of the frail elderly participating in our study showed a decrease in respiratory functions of about 9%, which is much larger than the annual decline of about 1% reported in the study conducted in 858 community-dwelling elders. However, after initiation of pulmonary rehabilitation, improvement in inspiratory volumes and inspiratory muscle performance was observed, as well as FEV1 among the frail elderly in our study. This seems consistent with the findings of Ja Young et al, in which respiratory rehabilitation using incentive spirometer exercise increases inspiratory volumes and inspiratory muscle performance, associated with improvement in FEV1 in 25 cerebral palsy patients. Taken together these results suggest that static maximal respiratory pressures will decrease with aging without the intervention of respiratory rehabilitation. This being the case, and if respiratory rehabilitation is effective to prevent disability in the elderly, as our study indicates, we believe that it should be included within the “Secondary Preventive Services.”

**Study limitations**
The present study had a number of limitations. Firstly, we did not provide a control group, and secondly we used only a single center to recruit subjects. In addition, the lack of follow-up was also a major limitation. Questions remain about the sufficient duration of rehabilitation, the best duration for a training session, intervention frequency, and the long-term effects of the respiratory rehabilitation. Confirmation from further population and randomized controlled trials is needed to increase the generalizability of our findings.

**Conclusions**
The results of our initial evaluation and pre-training evaluation showed that swallowing function, ADL, and QOL actually decrease in patients who received only usual rehabilitation and is, therefore, inadequate
rehabilitation for many frail elderly. Our post-training results, however, showed that swallowing function, ADL, and QOL are improved by the addition of respiratory rehabilitation to an usual rehabilitation program, and additionally that such improvements in respiratory and swallowing function are thought to lead to the prevention of aspiration pneumonia in frail elderly.

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Conflict of interest
The authors declare no conflict of interest.

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References


